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1. MANAGEMENT

Gas Industry Expansion

The Soviet Gas Goof. C. L. Adams. *Petrol. Eng. 32,* E-2 (1960) April (4 pp.)

This article explores the delayed but currently all out effort of the Soviet Union to develop its natural gas resources. Under Stalin's rule, development of gas energy was held back in favor of coal because coal reserves were huge and considered greater than oil and gas. Now, however, the Soviet Union has drawn up a master timetable for overtaking the U. S. in total industrial output by 1970. But the American gas industry during 1959 already surpassed the USSR's maximum 1972 gas production goal of 11,296 billion CF. Over 80% of Russia's gas production in the 1959-65 period has been allocated for use as an industrial fuel. Many open-hearth and blast furnaces, cement plants and thermal power stations are slated for conversion from coal to natural gas during the Seven-Year Plan. The Soviets are counting on substantial increases in productivity to result from this changeover.

Transwestern Builds an "Advanced Inch". J. F. Ebdon. *Gas 36,* 57 (1960) May (7 pp.)

Southern Counties Gas Co., Southern California Gas Co., and Pacific Lighting Gas Supply Co.—all based in Los Angeles to serve most of Southern California and all operating subsidiaries of Pacific Lighting Corp.—were certified by California's PUC to team-deliver 705 MMCF/day of out-of-state gas at the end of 1955. Today, they have a permit to deliver over 1143 MMCF/day of out-of-state gas from El Paso and 350 MMCF/day from Transwestern.

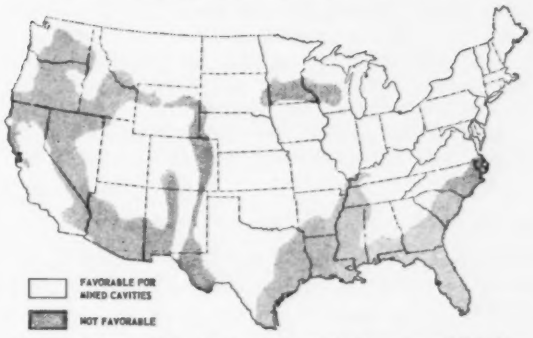
Growth of the Mexican Gas Industry. A. G. Rojas. *A.G.A. Monthly 42,* 28 (1960) April (4 pp.)

There are, at present, two important gas producing areas in Mexico. One of them is the Reynosa district, located in northeastern Mexico and the other is the Macuspana district, in the southeastern part of the country. Summing up all present production from gas fields and from important oil fields the Mexican gas production is 900 million CF of gas per day, which will increase rapidly when present gas lines under construction and under program will be finished. Pemex has a program to establish a group of important petrochemical plants, and orders for the equipment of some of them have already been placed. At the end of 1959 there were 3 big absorption plants in the country, and engineering work was being done to build additional absorption plants. A number of petrochemical plants are also on the program and their scheduled capacities are listed.

Mexico Has Active Program of Oil and Gas Development. L. J. Logan. *World Oil 150,* 162 (1960) May (6 pp.)

Detailed information on Mexican fields and properties is presented. A map illustrates oil and gas fields, refineries, natural gasoline plants, and pipe lines for moving crude oil, natural gas and petroleum products. Principal fields are in northeastern Mexico, the Tampico area, around Poza Rica and in the Isthmus. Production is about 300,000 bbl of crude and natural gas liquids per day.

Geological Formations Suitable for Construction of Underground Storage Caverns



(Adapted from *Planning for Mined Underground LPG Storage.* See abstract below)

LPG

Planning for Mined Underground LPG Storage. S. E. Scisson. *Oil Gas J. 58,* 141 (1960) May 2 (3 pp.)

Mined underground caverns for the storage of LPG have been well accepted by industry since their development 10 years ago. There are now 29 storage caverns either completed or under construction in this country with a total capacity of nearly 5 million barrels. They are located in 9 states and 15 different companies are either owners or part owners of such facilities. A map shows suitable areas of construction for caverns with the proper geological formations in the U.S.

The 1960 Survey, a Regional Study. *Butane-Propane News 22,* 34 (1960) May (14 pp.)

Article comprises a 13-page comprehensive statistical study of the LP gas industry. In presenting the material the editors subdivided it by subjects into six groups: the dealer's operating facilities and methods; his customers; his appliance sales records for 1959 and forecasts for 1960; his 1959 heating sales records and 1960 forecasts; his carburetion sales in 1959 and 1960 forecasts; and his expansion plans for 1960.

Research

R&D Becomes an Industry Necessity. *Chem. Eng. 67,* 78 (1960) April (4 pp.)

Less than 2% of gross national product is devoted to the conduct of research and development in the United States. It is expected that the nation's total research bill for 1959 will be over $8 billion, growing from about $2 billion in 1946. These figures exclude testing and evaluation expenditures, which may have been included as research and development in recent years. Currently the government supplies funds to support 51% of the United States' total research and development with industry supplying 46%. Colleges, universities and other institutions supply funds for the remaining 3%.

Gas Industry Management

Aggressive Selling and Offbeat Ideas Spark Rebirth of Arkla Gas. G. T. Kinney. *Oil Gas J. 58,* 80 (1960) April 18 (5 pp.)

Expand, sell, diversify, stimulate and actually build a new industry—this is the policy that has created markets for Arkansas Louisiana Gas Co. Its development of gas air conditioning and other big load builders has made Arkla a model of how to boost year-round gas sales.

Helium

NNG Proposes $75 Million Investment for Helium Recovery under Federal Program. *Gas Age 125,* 47 (1960) April 28.

Northern Natural Gas Co. has recently offered its cooperation in a government effort to conserve helium, which is lost in large quantities every year in the consumption of natural gas. Company estimates that 1.5 billion CF is contained in the gas it transports annually. It is proposed that the government should immediately proceed to conclude contracts permitting the extraction of helium from natural gas pipelines where the helium is now being wasted.

Air Conditioning

Air Conditioning—Load Builder for the "Golden Sixties". P. Lady. *Gas Ind. 4,* 6 (1960) April (5 pp.)

Gas companies in every section of the country are building sales and service organizations to take advantage of the load-building potential of gas air conditioning. This stepped up activity is making air conditioning an important part of appliance merchandising. In the past, promotion was most vigorous in the southern and mid-western states but reports from other regions show that it will not be confined to these areas for very long. A review of all air conditioning units now on the market is presented. A survey made by *Gas Industries* shows the progress of a number of leading companies who started air conditioning promotion programs in recent years.

Foreign Activities

Argentina Nearing Oil Independence. *Oil Gas J. 58,* 122 (1960) April 25 (2 pp.)

The 1959 gas reserves of Comodoro Rivadavia of 56 trillion CM are being raised to 160 trillion CM for 1964. The oil reserves of 732 million bbl are being raised to 2,100 million by 1964. Production figures for oil and gas are just as startling. This year Comodoro Rivadavia basin will produce 153 million CF/day of natural gas. By the end of 1964, this will increase to 468 million CF/day. A 22-in. products and 24-in. natural gas pipeline is laid directly to Buenos Aires from the new northern (Campo Duran) basin and a third big line is planned from Comodoro Rivadavia.

British Gas Policy. *Coke and Gas 22,* 165 (1960) April (4 pp.)

A recent statement of policy, published by the Gas Council in the form of a booklet, gives details of the plans proposed by the British gas industry for seven years ending March 1966. In planning the present and long-term development of the industry, policy considerations are reviewed and summarized.

French Pipeliners Cross the Sahara Desert. D. M. Taylor. *Pipe Line Ind. 12,* 36 (1960) April (4 pp.)

The 24-in. line from Hassi-Messaoud to Bougie on the Mediterranean is now complete. Another crude line is under construction and a gas line is in the engineering stage. Financing, construction and future outlook are outlined.

The Lacq Gas Field. L. T. Minchin. Part 1. *Coke and Gas 22,* 118(1960) March (4 pp.); Part 2. *Coke and Gas 22,* 161 (1960) April (4 pp.)

At Lacq a complete new factory has grown up in two or three years. The gas it produces is transmitted across France through 1000 miles of high-pressure trunk main, most of it laid since exploitation began in 1957. Sulfur is already being produced at the rate of 700,000 tons per year and with it 70,000 million CF of purified methane. These figures will be doubled when the second half of the installation comes into operation, which is planned for 1961. The principal byproducts and their purification methods are discussed. Engineers are already talking about an extension of the grid to the Channel coast and the Low Countries, and if the Sahara gas reaches France by pipeline this may well boost the French economy to a very significant degree.

Customer Service

A Systematic Approach to Quality Control. G. L. Morrow. Paper DMC-60-4. (New York: American Gas Association, 1960, $.25.)

A formal and systematic program was adopted by Peoples Gas Light & Coke Co. in order that quality of work performed by servicemen and by the district could be more meaningfully measured and analyzed. The benefits are discussed.

Corrosion

Organization and Operation of Corrosion Field Forces. L. F. Heverly. *Corrosion 16,* (1960) May (5 pp.)

Duties and functions of corrosion control personnel in a natural gas pipeline company are outlined. Topics discussed include organizational setup of the company's corrosion section, handling and processing of work order requests, duties of the corrosion supervisor, duties of the division corrosion technician, and education and training of district corrosion personnel. Considerable data are given on company-recommended cathodic protection installation procedures.

Hydrogen

Big Future for Hydrogen Processing. H. N. Olson and P. E. Schneider. Paper presented to Western Petroleum Refiners Association, Texas, January 1960. Condensed in *Petrol. Refiner 39,* 256 (1960) April (2 pp.)

Projected increase in capacity of presently large uses,

in conjunction with tremendous potential growth of presently small uses, make it very likely that overall consumption of synthesis gas and hydrogen will increase rapidly. It is estimated the total U. S. consumption in 1965 will be in the range of 1000 to 1250 billion CF per year. This is about twice the present capacity.

Cost Accounting

Capital Cost Estimates for Process Industries. J. W. Hackney. Part 1. *Chem. Eng. 67,* 113 (1960) March 7 (18 pp.); **Estimating Methods.** Part 2. *Ibid.,* 119 (1960) April 4 (16 pp.)

This two-part report collects and integrates established and new estimating methods and procedures. Part 1 covers the independent procedures for estimating individual portions of project costs, such as estimating of equipment, material, labor, and design and field expenses. Part 2 includes appraisals of methods with a discussion of project information and time required for estimating as well as relative accuracy of each method. The basic data to prepare and make uncertainty ratings for process-plant projects are also included.

Radioactivity Applications

What Radiochemistry R/D Forecasts for Industry. R. C. Koch. *Research/Development 11,* 140 (1960) April (14 pp.)

The increase in utilization of radioactive methods in industry has been enhanced by producing increasingly larger quantities of radioactive isotopes as a byproduct of the development and operation of nuclear reactors. Development, economic benefits and important savings are described. Various industrial applications are discussed.

Acetylene

Acetylene Plan: Lower Price, Higher Profit. *Chem. Week 86,* 13 (1960) April 2 (2 pp.)

Plan to produce acetylene from natural gas at a price 10-12% lower than the acetylene-from-calcium-carbide price, and still earn a higher rate of return on equity, is in the making. If the scheme works, it could profoundly affect the acetylene industry's long-range growth pattern. Air Products Inc. figures that such a venture would be economically feasible for three reasons: 1) there should be savings in serving multiple, close-at-hand customers; 2) additional products as nitrogen, oxygen and argon would broaden the company's industrial gas business; 3) and the company would build, own and operate the partial-combustion plant.

The Production of Acetylene by Methane Pyrolysis. P. W. Sherwood. *Gas J. 302,* 58 (1960) April 13 (2 pp.)

As yet, the bulk of acetylene is produced from calcium carbide, its conventional source. The growing demand for acetylene has been met by methane pyrolysis. It is estimated that natural gas is today the raw material for some 12% to 15% of acetylene produced in the U. S. Total capacity for methane-derived acetylene is approximately 250 million lb per year, equivalent to 28,000 million CF of natural gas. The key to the economic feasibility of producing acetylene from methane is large plant size. Installations of this type call for high capital cost plus the cost of an oxygen plant.

2. ENERGY SUPPLY AND ECONOMICS

Gas Reserves

U. S. Hydrocarbon Reserves Set New Record. D. E. Lambert. *World Oil 150,* 119 (1960) April (2 pp.); **Reserves Again at All-time High.** *A. G. A. Monthly 42,* 3 (1960) April (4 pp.); **Natural Gas Reserves in U. S. Climb to Record 262 Trillion Cubic Feet.** *Gas Age 125,* 19 (1960) April 14 (5 pp.); **Upturn in Production Brings U. S. Oil Reserves to All-time High.** *Gas Age 125,* 24 (1960) April 14 (2 pp.)

Proved recoverable reserves of natural gas in the United States advanced to an all-time high of 262.6 trillion CF in 1959, as announced in a joint report by the American Gas Association and the American Petroleum Institute. Gross additions to reserves last year totaled nearly 20.9 trillion CF, including 5.8 trillion CF newly discovered and 14.9 trillion CF revisions. New reserves discovered were the third highest on record. Proved reserves of crude oil and natural gas liquids totaled 38.2 billion bbl last December 31, an increase of 1.5 billion bbl over 1958. Annual liquid hydrocarbon production totaled 2.87 billion bbl, up 154 million bbl over the 1958 total.

Oil Shale

Oil Shale—Energy for the Future. F. L. Hartley and C. S. Brinegar. Section II—Paper 4. New York: Fifth World Petroleum Congress, 1959.

The significance of world oil shale deposits, as related to conventional crude oil reserves, is outlined. Present and past ventures devoted to the commercialization of shale oil are reviewed. World energy sources and utilization rates are examined. The impact of economic factors upon energy source decisions is stressed. Recent major research on oil shale is described. Products available from oil shale are considered from both quantitative and qualitative standpoints.

Recent Improvements and Development Work Concerning Oil Shale Processing at Kvarntorp, Sweden. E. K. B. Schjanberg and A. R. L. Brandberg. Section II—Paper 30. New York: Fifth World Petroleum Congress, 1959.

Swedish oil shale yields little oil, and the production of the Swedish Shale Oil Co. is therefore based on an extensive recovery of gaseous products. Consequently, only externally heated retorts are used and the pyrolysis residue is used as heat source in the Bergh-Kvarntorp-method. The ovens of this type have recently been further improved by a new retort design allowing 50% increase in production. Application of this method to foreign shales is exemplified. Two new gas treating plants have been started. The first one is based on the Avox process for catalytic removal of oxygen from the hydrogen-sulfide containing pyrolysis gas. The second

one is a plant for steam cracking of the dry gas and synthesis of ammonia. Two methods for utilization of oil shale fines have been investigated, namely, combustion and pyrolysis with subsequent gasification of the shale coke. The feasibility of the combustion has been demonstrated in large scale tests. The pyrolysis-gasification process uses the fluidization technique and is discussed on the basis of tests carried out.

Shale Oil

Union's Shale-Oil Plans Are on the Shelf. *Oil Gas J. 58,* 73 (1960) May 2

The combination of a low depletion allowance and depressed crude prices has resulted in the shelving of shale-oil process plans of Union Oil Co. of California. An experimental shale retort, operated by the company near Rifle, Colo., will be dismantled.

Fuel Cells

Molten Carbonate Cells with Gas-Diffusion Electrodes. D. L. Douglas. *Ind. Eng. Chem. 52,* 308 (1960) April (2 pp.)

To investigate the behavior of electrodes of the gas-diffusion type in molten alkali carbonate electrolyte, a ternary mixture of lithium, sodium and potassium carbonates was selected as the electrolyte. This mixture offered a wide temperature range for study because of its thermal stability. The use of a free-liquid electrolyte in such high temperature cells has not been previously reported. Preliminary experiments seem to indicate that gas-diffusion electrodes can be readily fabricated. Performance approximates that obtained with diaphragm cells and may be expected to improve when parallel close-spaced structures are used. Corrosion is most likely to limit the utility of this general cell design.

Electric Energy from Fuel Cells. G. Salvi and A. Fiumara. *Rivista dei Combustibili 14,* 149 (1960) Feb. (23 pp. Italian text.)

Review of developments and status of fuel cell research, including principles and applications, is presented.

Esso Catalyst Improves Oil Fuel Cell. *Petrol. Week 10,* 67 (1960) May 6 (2 pp.)

Hydrocarbons and petroleum derivatives can now be used as fuel for the fuel cell, at normal temperatures and pressures, because of a technique recently perfected by Esso Research & Engineering Co. The low molecular weight petroleum products used as fuels may be either in gaseous or liquid form. Successful operation has been carried out at Esso with ethane, propane and ethylene, and among the liquids, with methanol. The ultimate goal is to use a regular distillate fuel oil in the fuel cell. The secret of the technique lies in mixing adequate catalysts into the material used to make the electrodes.

New Entry in Fuel Cell Race. *Chem. Week 86,* 72 (1960) April 30 (2 pp.)

Goal of GE's development program is a fuel cell power source that can be mass-produced as equipment for military applications. The device is designed to deliver 200-watts of 24-volt direct current for 14 hours on a single 6-lb canister of fuel. It equals the output of a 55-lb engine generator or 80 lb of batteries. The electrolyte is a plastic ion-exchange membrane. This feature avoids problems of simultaneous triple contact between gaseous fuel, liquid electrolyte and solid electrodes.

Fuel Cells. A. M. Moos. *Ind. Eng. Chem. 52,* 291 (1960) April (2 pp.)

Technical feasibility of a new electrode and electrolyte combinations are outlined and their possible commercial applications discussed.

Fuel Cell Panel Discussion. G. J. Young. *Ind. Eng. Chem. 52,* 310 (1960) April.

Summary of the major points raised in a discussion of fuel cell construction and operation as well as on future prospects of application is presented.

Fuel Cells as Electrochemical Devices. H. A. Liebhafsky and D. L. Douglas. *Ind. Eng. Chem. 52,* 293 (1960) April (2 pp.)

General outline is given on the purpose, requirements and characteristics of fuel cells.

Carbonaceous Fuel Cells. H. H. Chambers and A. D. S. Tantram. *Ind. Eng. Chem. 52,* 295 (1960) April (2 pp.); **Hydrogen-Oxygen Fuel Cells with Carbon Electrodes.** K. Kordesch. *Ibid.,* 296 (3 pp.); **Catalysis of Fuel Cell Electrode Reactions.** G. J. Young and R. B. Rozelle. *Ibid.,* 298 (3 pp.); **Electrode Kinetics.** L. G. Austin. *Ibid.,* 300 (2 pp.); **The High Pressure Hydrogen-Oxygen Fuel Cell.** F. T. Bacon. *Ibid.,* 301 (3 pp.); **High Temperature Fuel Cells.** G. H. J. Broers and J. A. A. Ketelaar. *Ibid.,* 303 (4 pp.); **Nature of the Electrode Process.** E. Gorin and H. L. Recht. *Ibid.,* 306 (3 pp.)

For abstracts of the above mentioned articles see *Gas Abstracts 15,* 365, 367.

Energy Sources

Status of Free Radicals. J. L. Franklin. *Chem. Eng. Progress 56,* 63 (1960) April (5 pp.)

Survey of investigations into methods of isolating free radicals and the prospects for their practical application is presented. If trapped radicals are ever considered for commercial chemical process applications, several problems will demand serious consideration. Among the most serious of these are the very low temperatures involved and the accompanying problems of heat economy. Most of the successful trapping of radicals so far has been at 4°-20° K, a temperature very difficult and expensive to achieve. In a few instances radicals have been stabilized at higher temperatures in ice or certain glasses. No serious study of this problem has been made.

Free Radical Fuels. G. C. Szego. *Chem. Eng. Progress 56,* 60 (1960) April (4 pp.)

Free radicals and similar nonredox systems represent a theoretical possibility for the storage of energy in sufficient density to outperform chemical propellants for rocket propulsion. Feasibility has not yet been established for such systems, but dissociated molecules have not been stabilized in sufficient quantity to appear as attractive prospects. Metastable inert gases require experimental verification of their half lives to establish bases for further evaluation.

Solar Heat

Radiation, Convection and Conduction Coefficients in Solar Collectors. *Bull. Res. Counc. Israel 6C,* (Technology) 155 (1958) Aug. (22 pp.) [From *Appl. Mech. Rev. 13,* 206 (1960) March.]

Paper discusses at length the heat-transfer processes which contribute to the loss of heat from solar collectors. The most valuable feature is in showing how use of the more nearly correct value of 0.88 for glass hemispherical emissivity in place of 0.96 as originally assumed by Hottel (*ASME Trans. 64,* 91-104, 1942) requires reassessment of the relative contribution of radiation and convection. Paper gives much quantitative data of value in computing the performance of solar absorbers, particularly with the development in recent years of radiation surfaces which absorb short-wave solar radiation, but reflect long-wave infrared radiation.

A. Whillier, South Africa

Tar Sands

Petroleum Substitutes from Tar Sands. D. S. Pasternack. *Chem. Eng. Progress 56,* 72 (1960) April (4 pp.)

Economical recovery of oil from the Athabasca tar sands, one of the major oil reserves, is discussed. Properties, geology and oil recovery methods such as solvent extraction, hot and cold water washing, and fluidized retorting are outlined. Economic aspects based on mild hydrogenation for desulfurization indicates a 5.5% return on plant investment.

Thermoelectricity

Four Ways to Turn Heat into Electricity. *Business Week,* 155 (1960) April 9 (2 pp.)

At the moment, there are at least four different approaches to energy conversion: the thermoelectric generator, fuel cell, thermionic generator and the magnetohydrodynamic generator. Westinghouse Electric Corp. announced that it has working models of all four types because it is impossible to decide on any one system. A future choice will probably hinge on such factors as environment, space, heat source and desired efficiency.

Lightweight Thermoelectric Generator Developed by General Instrument Corp. *Gas Age 125,* 26 (1960) April 14; **The Propane Fueled Thermoelectric Generator.** *LP-Gas 20,* 50 (1960) May.

The new generator, which employs thermopiles of semiconductor elements to convert the heat of the burning propane into electricity, produces five watts of power as long as the fuel supply lasts. It has been designed to run for approximately a year on a 200 lb tank of propane. By storing 1000 lb of propane gas with the generator, it could run unattended for five years, say General Instrument engineers.

Fuel Cells

Double Skeleton Catalyst Electrode. E. Justi, W. Scheibe and A. Winsel. (Assigned to Ruhrchemie A. G. and Steinkohlen-Elektricitat A.G., Germany) U.S. 2,928,891 (1960) March 15.

A catalytic double skeleton electrode is claimed for use as a gas diffusion electrode in a fuel cell, in which a powdered Raney nickel alloy is mixed with powdered carbon, nickel, cobalt or iron, pressed at 3000-7000 kg/cm^2 to desired shape, sintered at 600-1000° C and extracted with KOH to remove aluminum.

Thermoelectricity

Fluid Cooling Apparatus. E. C. Levit (assigned to Whirlpool Corp.) U.S. 2,931,188 (1960) April 5.

Apparatus is claimed for cooling and heating separate bodies, comprising: a thermoelectric structure having spaced hot and cold junctions; means for thermally contacting one body of fluid with the cold junctions for cooling said fluid; means for thermally contacting a portion of the cooled fluid with hot junctions for heating the fluid, and supplemental means for cooling at all times the fluid receiving heat from the hot junctions.

3. NATURAL GAS AND PETROLEUM PRODUCTION

Drilling

Efforts to Develop Improved Oilwell Drilling Methods. L. W. Ledgerwood, Jr. *J. Petrol. Tech. 12,* 61 (1960) April (14 pp.); **Needed Now: A Better Understanding of the Basics of Earth Boring.** *Oil Gas J. 58,* 127 (1960) May 9 (15 pp.)

Industry's efforts to develop new drilling tools and systems is divided into two general categories. Part 1 "Rock-Attack Developments" outlines past and present attempts to develop new methods of earth boring which would be economically superior to rotary drilling by virtue of greater drilling rate and/or longer bit life. Part 2 "Efforts not Related to Rock Attack" reviews work concerned with novelty other than the method of rock attack.

How to Stabilize Long Exposed Shale Sections. W. J. Weiss, W. L. Hall and R. H. Graves. *World Oil 150,* 154 (1960) April (9 pp.)

The main problems of well bore instability are associated with shale bodies which undergo spontaneous self-dispersion upon contact with water or conventional drilling fluids. Studies of the surface chemistry of clays led to a shale control mud system which couples a high filtrate calcium level with a controlled alkalinity environment. Samples of dispersing shale in contact with this filtrate undergo a progressive solidification so that, within reasonable time, they become hard and insensitive to even fresh water.

Six Variable Factors that Affect Penetration Rate. P. L. Moore and C. Gatlin. *Oil Gas J. 58,* 118 (1960) April 11 (3 pp.)

Article summarizes the more recognizable variables affecting penetration rate such as: bit weight, rotary speed, drilling-fluid properties, drilling-fluid hydraulics, rock properties and bit selection. Their general effects

as observed in laboratory and field experiments are discussed.

Slats Honeymon Converts Rig from Gas to Electricity. C. Barrow. *Drilling 21,* 70 (1960) April (4 pp.)

Rig in Caddo County, Okla., may be the forerunner of the drilling unit of the future. The rig is an innovation of progress made by the drilling industry and presents a conversion of gas-butane power to all-electric power. The rig is designed around a Mid-Continent Supply Drawworks with a jack-knife type mast. The power is furnished by an electric motor to power the drawworks.

Exploration

Electronic Computers Aid Many Exploration Phases. E. J. Assiter. *World Oil 150,* 105 (1960) April (7 pp.)

Article is categorized into five general exploration topics: geological mapping, log interpretation, statistical property evaluation, reflection seismograph data interpretation and gravity data interpretation.

How to Do Refraction Work by Remote Control. P. Vetterlein. *World Oil 150,* 114 (1960) April (3 pp.)

New remotely controlled refraction seismograph system has been developed and used in the field, simultaneously providing advantages of joint registration, methods simplification, and reduction of operating personnel. The system is especially useful to evaluate large, remote areas. In addition, a special application of this remote control system is found in offshore operations. The receiving station can be installed in a fixed buoy.

Panhandle-Hugoton Busiest U.S. Area. *Oil Gas J. 58,* 148 (1960) April 25 (5 pp.)

Hugoton-Panhandle region, busiest oil and gas hunting ground in the U.S. today, covers the Oklahoma and Texas panhandles, southwestern Kansas, southeastern Colorado and northeastern New Mexico. This Spring there are 275 active locations in the area with 232 companies working throughout the region. Success ratios range from as high as 88% in Harper County, Okla., to 38% for the entire area. Logs, discoveries and fields are listed.

Geology

How to Make Geochemical Exploration Succeed. S. J. Pirson. *World Oil 150,* 93 (1960) April (4 pp.)

It is imperative to combine geochemical surveys not only with geological and geophysical information but also to combine geochemical measurements of diverse but supporting response. After World War II prospecting flourished in the U. S., but most of it was conducted by consulting firms. Geochemistry research, however, has become in recent years a major effort of most petroleum research laboratories, not only for devising techniques of finding petroleum directly, but also for geological age determination, source bed investigations, determination of processes of oil and gas migration and accumulation, oil origin and so on. Author discusses application of geochemistry to exploration.

Palynology as a Working Tool. J. F. Grayson. *Oil Gas J. 58,* 136 (1960) April 25 (5 pp.)

Megascopic plant fossils have been of little or no use to exploration geologists because they are rarely recovered from well samples. The discovery of polospores in sedimentary rocks has changed the picture. The principles of palynology indicate that this new science may provide the geologist with more accurate information. A clear understanding of the polospores of the geologic column, their ranges, frequency variations and relationship to modern and fossil plants must be obtained. Only then can correlations and datings be made with genuine confidence.

Palynology Has Important Role in Oil Exploration. W. S. Hoffmeister. *World Oil 150,* 101 (1960) April (4 pp.)

Palynology, now an accepted tool in oil exploration, includes microfossils that are useful in making age determination, correlating wells and outcrop sections and suggesting favorable areas for oil exploration by interpreting environment. Extraction techniques as well as groups of microfossils used are outlined briefly in the article.

Why Sedimentary Structures Show High Self-Potentials. O. E. Campbell. *World Oil 150,* 97 (1960) April (2 pp.)

Geochemical anomaly is a natural phenomenon consisting of a concentration of minerals in a halo pattern around or over a geologic structure and/or an oil accumulation. The author proposes a theoretical explanation for the electrical anomalies measured in the horizontal direction at the earth's surface. A practical explanation is also presented, based on the facts and data accumulated by the author.

Phase Equilibria

Relationship of Vapor-Liquid Equilibrium Ratios at Dewpoint Pressure to Compressibility Factors and Composition of Gas-Condensate Fluids. C. K. Eilerts, N. Potts and B. A. Baker. Section II-Paper 28. New York: Fifth World Petroleum Congress, 1959.

Relationship between vapor-liquid equilibrium ratios at the dewpoint and composition of gas-condensate fluids is used to develop a means of calculating equilibrium ratios for phase-boundary states. The vapor-liquid equilibrium ratio of all components of a fluid is unity at the critical state but departs from this value as the difference between the temperature of interest and the critical temperature increases. The equation for calculating the equilibrium ratio is designed to take this relationship of temperatures into account for both dewpoint and bubble-point states. Composition of the liquid phase at the dewpoint, determined for seven fluids at separator and reservoir temperatures, was utilized to determine one of the parameters required in the equation of the equilibrium ratio. Two methods are described for calculating equilibrium ratios of components of gas-condensate fluids at dewpoint temperatures in the range of 70° to 310° F when only composition of the fluid is known.

Reservoir Engineering

Characteristics of a Retrograde Condensate Reservoir Containing a Large Quantity of Carbon Dioxide. W. E. Bauman and F. V. Miles. *J. Petrol. Tech. 12,* 27 (1960) April (6 pp.)

The literature possesses limited data on reservoirs containing an appreciable quantity of carbon dioxide. The primary purpose of this paper is to present the fluid characteristics of a retrograde condensate system containing approximately 92 per cent carbon dioxide. The text includes the basic PVT studies as well as a discussion of surface separation equipment and problems associated with testing and producing the reservoir. Included also are geological and engineering characteristics of the reservoir and a review of corrosion problems.

Two-Phase Flow in Two-Dimensional Systems—Effects of Rate, Viscosity and Density on Fluid Displacement in Porous Media. R. G. Hawthorne. *Petrol. Trans. 219,* (Tech. Paper 8110) 81 (1960; 7 pp.)

Report is concerned with fluid displacement in porous media, in those cases where viscous and gravitational forces control the displacement. Such a system would usually be found in a sand body of large physical dimensions such as an oil reservoir, although it is possible to create such a system in the laboratory. It is shown that the position of the fluid interface can be predicted by numerical calculations using a basic idea presented by Dietz. Fluid flow is considered in a vertical plane in a homogeneous, porous medium of sufficient thickness that the capillary transition zone is small in comparison with that of the total reservoir. A theory developed by Dietz is used to make numerical calculations of the position of the fluid interface. The results for several conditions are compared with scaled model experiments.

The Volumetric Behavior of Natural Gases Containing Hydrogen Sulfide and Carbon Dioxide. D. B. Robinson, C. A. Macrygeorgos and G. W. Govier. *Petrol. Trans. 219,* 54 (1960) (Tech. Paper 8107. 7 pp.); summarized in *J. Petrol. Tech. 12,* (Petrol. Trans. section) 37A (1960) April

Experimental data have been obtained on the volumetric behavior of ternary mixtures of methane, hydrogen sulfide and carbon dioxide at temperatures of 40°, 100° and 160° F up to pressures of 3000 psia. The results indicate that the compressibility factors for this system do not agree with compressibility factors for sweet natural gases at the same pseudo-reduced conditions. The deviation increases as the temperature and methane content decrease. Discrepancies of up to 35 per cent were observed. A careful analysis has been made of the existing published data on compressibility factors for binary systems containing light hydrocarbons and hydrogen sulfide or carbon dioxide. It has been found that the deviation of actual from predicted compressibility factors for methane-acid gas mixture is a function of the methane content and the pseudo-critical properties of the mixture.

Secondary Recovery

Miscible Slug Flooding—A Review. F. F. Craig, Jr. and W. W. Owens. *J. Petrol. Tech. 12,* 11 (1960) April (5 pp.)

Published research, in large portion, has been concerned with the volume of solvent slug required to maintain miscibility between the reservoir oil and the scavenging gas. In this paper laboratory results are reviewed with particular emphasis on the general conclusion of the studies as applied to field application of miscible flooding. The factors affecting the portion of the reservoir swept by the miscible slug and reservoir conditions believed desirable for successful operation are discussed. Possible methods for improving the sweep efficiency are considered.

4. GAS CONDITIONING AND LPG RECOVERY

Absorption

Absorption and Humidification. M. Leva and Chin-Yung Wen. *Ind. Eng. Chem. 52,* 340 (1960) April (3 pp.)

Article reviews the whole field of absorption and humidification with over 70 references cited. Some original Japanese reports were also consulted for this review; however, Russian studies could be covered by way of condensed abstracts only. Topics discussed here are: new equipment, design correlation, cooling towers, agitated vessels, packed tower studies and liquid distribution in packed beds.

Carbon Dioxide Removal

The Fluor Solvent CO_2-Removal Process. A. L. Kohl and P. A. Buckingham. *Oil Gas J. 58,* 146 (1960) May 9 (7 pp.); **Natural Gas Purifier.** *Chem. Week 86,* 44 (1960) May 7; *Petrol. Refiner 39,* 193 (1960) May (4 pp.)

Article discusses new process developed to more economically extract CO_2. Preliminary analysis indicated that the desired objectives could best be met by the use of a substantially anhydrous, nonreactive organic solvent as an absorbent for carbon dioxide. An operation based on physical solution rather than chemical reaction would eliminate or greatly reduce heat requirements for stripping and, if a solvent with sufficient capacity for CO_2 were found, the circulation rate and therefore, the pumping requirements, could be minimized. The initial period of research consisted primarily of screening literally hundreds of possible solvents and selecting the most likely candidates for testing in a bench-scale gas-purification pilot plant. Article presents development of laboratory bench and plant version of solvent process, with design and operational cost data. (See also Patent No. 2,926,751 on the following page.)

Hydrogen Sulfide Removal

Chemical Purification of Gas. Dry Purification. M. M. Pataud. *Compt. Rend. Congr. Ind. Gaz 76e Congr.* Paris, 91 (1959) June (33 pp. French text)

This report is a continuation of the author's study published in 1958. The subject is subdivided into the following sections: purifying vessels; flow systems; vessel connections; flow controls comprising valves, baffles, etc.; auxiliaries of air supply; handling of purified material. Each section gives diagrams and illustrations of many varieties of equipment currently in use in the industry with special detail on flow practice and handling systems.

New Data for Hot Carbonate Process. H. E. Benson and J. H. Field. *Petrol. Refiner 39,* 127 (1960) April (6 pp.)

Design is based on obtaining the most favorable combination of capital and operating costs. The availability and cost of steam are major factors to be considered. If the cost of steam is high, flash cooling, a modification of the basic hot carbonate technique, can be employed to decrease the consumption of steam. At the same time cooling of the regenerated solution is achieved. Pilot plant results show that the hot carbonate system is applicable for removing hydrogen sulfide either in low concentrations, as in synthesis gas, or in high concentrations, as in sour natural gas. A high degree of purity to pipeline specifications can be achieved by the use of staging.

Separators

New Field Plant Now on Stream at Hassi-Messaoud. P. Lepee. *World Petrol. 31,* 58 (1960) April (2 pp.)

The new S. N. REPAL field processing plant at Hassi-Messaoud with a capacity of 150,000 bbl/d of stabilized crude went on-stream in Sept. 1959. Test lines and gathering lines connect each well to the center. At the center there is a very light, low-sulfur crude accompanied by a large quantity of gas: about 1100 CF of gas per barrel of stabilized crude (mainly methane, ethane, propane, some butane). The crude is degassed in three stages, at decreasing pressures. First stage consists of a battery of separators. The gases from the first and second separation stages are burned in a so-called "high pressure" flare. The third separation stage, operating close to atmospheric pressure, consists of vertical separators connected to four 15,000 bbl tanks.

Three-Phase Separators. W. F. Broussard and C. K. Gravis. *World Oil 150,* 127 (1960) April (6 pp.)

Basic principles of oil and gas separation have been covered in Part 1 of the production practices manual (see *Gas Abstracts 16,* 10 (1960)). This particular discussion concerns the separation of free water and oil. Free water can be separated from liquid hydrocarbons by retention time and absence of turbulence, without the aid of heat. Also, by definition, free water is not emulsified with another substance. The design and sizing of separators is outlined.

Carbon Dioxide Removal

Organic Carbonate Process for Carbon Dioxide. A. L. Kohl and F. E. Miller. (assigned to The Fluor Corp., Ltd.) U. S. 2,926,751 (1960) March 1.

In a process for pressure scrubbing of carbon dioxide from mixtures of gases, propylene carbonate is claimed as a selective solvent which is regenerated by flashing the rich solution in a separate pressure-reduction chamber from which CO_2 is recovered. Moisture also is removed. Additional regeneration of solvent may be obtained by air stripping the flashed liquid. (For similar patent No. 2,926,752 see *Gas Abstracts 16,* 78 (1960) April.)

Process for Carbon Dioxide Absorption. A. L. Kohl and F. E. Miller. (assigned to The Fluor Corp., Ltd., U. S. 2,926,753 (1960) March 1.

Ether acetates of the group consisting of butoxy diethylene glycol acetate and methoxy triethylene glycol acetate are used as carbon dioxide absorbents in a pressure scrubbing process. Regeneration of solvent is achieved by flashing the enriched solution in one or more stages to atmospheric pressure. The flashed solution also may be air-stripped. (For similar patent No. 2,926,752, see *Gas Abstracts 16,* 78 (1960) April)

Carbon Monoxide Removal

Method of Regenerating Ammoniacal Copper Solutions Utilized to Remove Carbon Monoxide from Gases. C. S. Morris (assigned to Phillips Petroleum Co.) U. S. 2,930,672 (1960) March 29.

Carbon monoxide is removed from ammonia synthesis gases by a process which scrubs the gases with ammonical copper solution. The solution is regenerated by passing it downward through a reflux zone for recovering ammonia, a heating zone to raise the temperature to 160°-180°F and a digestion zone to complete oxidation of CO. Control of cuprous and cupric ion to maintain CO removal is attained by bypassing a portion of contaminated solution past the reflux and heating sections.

Hydrogen Sulfide Removal

Removal of Hydrogen Sulfide from Gas Mixtures. H. S. Bloch and V. Haensel (assigned to Universal Oil Products Co.) U. S. 2,930,673 (1960) March 29.

Hydrogen sulfide may be removed from a gaseous mixture by passing the gas through a water-free slurry, or bed of pellets, formed by solid phosphates of the I and II group metals (Cu, Zn, Ag, Cd, Hg) and supported on inert carrier at superatmospheric pressure and 100°C, to cause formation of metal sulfide and free phosphoric acid. The sulfided material is regenerated in a separate vessel by reduction of temperature and pressure and may then be recirculated.

Separators

Internal Purifier. C. L. Campbell. (assigned to Centrifix Corp.) U.S. 2,929,465 (1960) March 22

A centrifugal separating apparatus is claimed with comprises an outer cylindrical shell with one open and one closed end and having tangential inlet openings in its side wall, and an inner cylindrical shell radially spaced from outer shell also with tangential inlet opening slots and vanes in its side wall designed to reverse the direction of fluids flowing through. These shells form a central chamber and an outer annular chamber which

are both closed at the bottom by a flat plate, and with the inner vented upward by lower and upper divergent-lipped nozzles. Thus the entering gas is subjected to three successive centrifugal motions to baffle out any suspended matter.

5. NATURAL GAS TRANSMISSION

Automation

How Automated Are You? J. L. Ryan. *Oil Gas J. 58,* 100 (1960) May 2 (4 pp.)

Since automation has become an important phase of our industry, the Natural Gasoline Association of America prepared a questionnaire on automation and sent it to all association members. Its purpose was to determine the extent of automation in the natural gasoline industry, the type of equipment in use and the point of application. The results showed that the unattended or partially unattended compressor station was an area of activity in which nearly all the companies were involved. Beyond this, there was considerable divergence.

Remote Control of Offshore Compressors by Microwave. W. E. Matthews. *Gas Age 125,* 36 (1960) April 14 (6 pp.)

Remote control of compressors via microwave is only one of the new concepts necessary to meet the challenge of offshore production. Even with some design features of questionable utility, the installation described here has compared favorably in operating cost with those of land compressor stations. The intangible benefits have been even more important.

Compressibility

Zs for Propane and Methylacetylene. P. P. Dawson, Jr. and J. J. McKetta. *Petrol. Refiner 39,* 151 (1960) April (4 pp.)

Compressibility of propane and of methylacetylene were determined below 2 atm pressures and at temperature range of $-30°$ to $+75°$C. The basic apparatus used was originally developed by Edwards for the determination of the densities of industrial gases. The apparatus was modified to increase accuracy but the principle of operation remained the one of a gas buoyancy balance. Second virial coefficients were calculated from mean values of the compressibility factors. The error in the compressibility measurement was approximately $\pm$ 0.04%.

Dispatching

Fully Instrumented Gas Dispatch System. J. A. Brady. *Am. Gas J. 187,* 17 (1960) May (6 pp.)

Anticipating continued growth in its natural gas supply and sendout, Milwaukee Gas Light Co. has modernized and expanded its gas dispatching facilities. The new facilities are composed of four basic phases. A computer system measures natural gas flow through five company gate stations. Pressures, temperatures and other gas flow information are indicated on an analog telemetering system. Other phases are a high-low alarm system for monitoring pressures at remote locations and industrial metering instrumentation for interruptible load control.

Fluid Flow

Results of Follow-up Tests on Internally Coated Pipe. C. H. Klohn. *Pipe Line Ind. 12,* 30 (1960) April (3 pp.) **Test Shows Internal Coating Boosts Gas Flow.** C. H. Klohn. *Oil Gas J. 58,* 177 (1960) May 2 (3 pp.)

A series of flow tests were performed in December, 1959, on a 12-mile section of 24-in. OD pipe to determine the value of internal coatings to gas transmission. These tests were a follow-up of similar tests conducted in November and December, 1958, and described in July, 1959, *Pipe Line Ind. 11,* 36. It may be concluded that the 1958 test results were reproduced within a very close tolerance of experimental error, and from this it can be seen that there has been no apparent deterioration of the interior coating.

Predicting and Controlling Transient Pressures in Long Pipelines. R. R. Burnett. *Oil Gas J. 58,* 153 (1960) May 2 (8 pp.)

Pressure surges generated in Trans-Arabian Pipe Line Co.'s pipeline by tripping off pumping units, require careful analysis to avoid overstressing the pipe. Control of surge pressure by automatically reducing upstream pressure proved to be generally satisfactory in the application described. This method requires detailed analysis of surge pressures and a dependable communications system. The analytical solution of wave-front attenuation has been used successfully. The numerical solution, developed mainly for pressure-velocity-time relations at a fixed location, offers a means for solving a wide range of transient-flow problems with a reasonable amount of effort.

Metering

United Gas Develops Easy-to-Operate Orifice Meter Chart Scanner and Computer. *Gas 36,* 132 (1960) May (5 pp.)

Instrument described rapidly and automatically scans the circular charts with an optical system, and the associated electronic digital computer in conjunction with a special logarithmically coded disk performs the accumulative flow computation. Very little operator effort or skill is required to operate this instrument and absolutely no operator judgment is involved in determining the pressure levels.

Pipeline Construction

Influence of Location on the Design of Lower Mississippi Pipeline Crossings. L. M. Odom. *Gas Age* 125, 27 (1960) April 14 (3 pp.)

The selection of the site for a particular pipeline crossing must be done very carefully so as to insure a successful crossing and to reduce the cost to a minimum. The requirement posed by the general alignment of the pipeline ordinarily reduces the length of river within which a selection must be made to a very few miles. The exact location of the site within this length is based on observations and records of the characteristics of the regimen

of the river, of the bank materials, previous activity of the river, and the work done and planned by the Corps of Engineers.

Jumping the Chesapeake-Delaware Canal. M. Fitzpatrick. *Gas 36,* 72 (1960) May (3 pp.)

Eastern Shore Natural Gas Co. was faced with one major crossing in extending its 8-in. line into southern Delaware and eastern Maryland. It was the Chesapeake-Delaware Intercoastal Canal. The overhead crossing was chosen because it solved a formidable problem and resulted in savings amounting to more than six figures. The Corps of Engineers favored the aerial solution because the unstable banks would not be disturbed. The Corps placed only one requirement: a clearance of 140 ft and foundations that would not interfere with the future expansion. The Clear Span design and method of erection, carefully developed over the past several years and proven in numerous crossings, offered the answer to the spanning problem.

Transwestern—the Pipeline. *Gas 36,* 117 (1960) May (13 pp.)

A 30-in. O.D. mainline originates at a compressor station near Roswell, N. M. and runs west for some 644 miles to the Colorado river. Four mainline compressor stations will power the project to enable an initial delivery of first 300 then 350 MMCF/day to move through the mainline to the Pacific Lighting Gas Supply Co.'s 34-in. pipeline which will conduct the natural gas on into California. Later, nine mainline stations will use 126,000 hp to compress 640 MMCF/day through the Transwestern system. The route, construction details and station controls are outlined.

YPF Pipeline Project Is Story of Amazing Logistics. P. Reed. *Oil Gas J. 58,* 107 (1960) April 11 (4 pp.)

The Campo Duran project in Argentina, now nearing completion for Yacimientos Petroliferos Fiscales (YPF), stands out among important projects of the world. It consists of a 1100-mile, 24-22-in. gas line extending from Campo Duran to Buenos Aires, and a 900-mile, 12-in. products line for moving propane, butane, gasoline, distillate, kerosine and gas oil/diesel. In addition to finished products, the products line makes large shipments of condensate designated as distillate. Furthermore this project is exceptional in the way of financing, purchasing and shipping.

Pipeline Operations

Strain Gages on Big-Inch Gas Pipelines. G. McClure. *Oil Gas J. 58,* 92 (1960) April 4 (5 pp.)

The American Gas Association conducted a program to determine some of the so-called secondary stresses in natural gas pipelines. The program involved extensive use of bonded-wire strain gages sometimes under adverse field conditions. A number of problems of gage application, waterproofing, wiring and instrumentation were overcome. Some of the problems and techniques used are described in this article with the hope they may be of use to others in field work.

Latest Techniques in Cleaning Lines with Detergents. J. N. White and A. Bartoszek. *Pipe Line Ind. 12,* 43 (1960) April (4 pp.)

Observations made as a result of the experience with detergent cleaning were: better control and results are obtained by cleaning shorter sections; detergent cleaning alone does not appear to give the desired increase in efficiency, therefore, supplemental runs should be made with wire brush cleaners, either before, during, or after the detergent; there is very little hazard involved in using detergents, including gasoline, when proper precautions are taken; the cost per mile for cleaning with detergents is equal to, or slightly less than, the cost of cleaning with conventional dry wire brush cleaners.

Piping

Code for Pressure Piping. *Gas Age 125,* 43 (1960) April 28 (6 pp.)

In addition to being legally required in many states, the B31.8 ASA Code, the pipeline industry's "Bible" for safety, has been voluntarily accepted by over 90% of gas companies. The code describes how pipe for transmission and distribution lines should be designed, how these pipelines should be constructed, and how the finished lines should be tested to be sure they were constructed properly. The code committee, which continues to make changes and revisions, intends to issue a new edition of the B31.8 about every three years.

Pressure Regulation

Noise Abatement at Gas Pipeline Installations. Noise Suppression at Pressure Regulating and Metering Stations. J. M. Sharp, G. Damewood, C. R. Sparks and M. T. Hanchett. Project NQ-23. (New York: American Gas Association, 1960, $3.50.)

The greater portion of this report is concerned with defining the nature of noise emitted from piping carrying high velocity gas flow and with prescribing methods for the suppression or elimination of such noise. Section 1 discusses sources of noise, means of noise propagation, accepted methods for the control of undesirable sound and vibration, and a listing of typical materials and methods for acoustical treatment. Section 2 presents the data and results of field tests. Section 3 contains results of laboratory and field investigations into various methods of noise abatement. Practical design considerations are treated in sections 4 and 5.

6. GAS AND LPG STORAGE

Generators

Generators of Low-Pressure Propane/Air at 6.5 or 13.5 th/m³. M. E. Mathieu. *Compt. Rend. Congr. Ind. Gaz 76e Congr.* Paris, 125 (1959) June (29 pp. French text.)

A considerable variety of automatic propane/air generators have been devised. The object of the present paper is to report on the study of this problem. Efforts were made to provide a novel solution to the question of control systems, which plays an important part in stabilizing

delivery pressure and hence calorific value. In addition, a systematic study of all components of these generators was made and they were supplemented with auxiliary systems and devices for safety purposes. On this basis three generator models were designed capable of producing low-pressure propane/air at 6.5 or 13.5 th/m³. One generator was designed to be installed beneath a building. Another was made to be readily adaptable to storage gasholders. Finally a generating riser was completed comprising a controlling gasholder, the whole assembly being capable of installation without modification.

Methane Liquefaction

Aluminum Tanks for the Sea Transport of Liquefied Natural Gas. W. Ferguson. *Gas J. 302,* 143 (1960) April 27 (4 pp.)

Northern Aluminum Co. Ltd. decided to investigate the design problems associated with aluminum tanks as a useful accompaniment to research of fabricating techniques and the properties of suitable aluminum alloys. The results of this study, made by Aluminum Laboratories Ltd at their Geneva office, cover features of ship and tank capacity, shape, expansion, stresses, gas pressures and reinforcement.

Underground Storage

Aquifers for Underground Natural Gas Storage. Part 2. Criteia fo Selection; Geology, Lithology, Economics. J. A. Kornfeld. *Am. Gas J. 187,* 31 (1960) May (4 pp.)

Engineering, geologic and economic factors employed for selection of aquifers for underground natural gas storage service are discussed. These basic factors are criteria for the determination of feasibility of conversion of underground folder aquifers and are outlined as follows: strategic location, economic feasibility, aquifer characteristics, reservoir performance characteristics. (Part 1, see *Gas Abstracts 16,* 81 (1960) April).

Liquefaction

Apparatus and Method for Fractionation of Gas. C. J. Schilling (assigned to Air Products Inc.) U. S. 2,932,174 (1960) April 12.

Air is separated into components by refrigeration liquefaction and fractionation by an improved heat exchange system. Impurities (CO_2) deposited as solids in reversing recuperators from two portions of incoming air are evaporated in successive stages by dividing the heat exchangers into proportional sections, and flushing with low and high pressure nitrogen fractions.

Method of Liquefying Helium. G. D. Mordhorst and K. R. Leonard (assigned to Beech Aircraft Corp.) U. S. 2,932,173 (1960) April 12.

A method of producing liquid helium is claimed in which two separate streams of helium, one at intermediate and one at high pressure, are passed through two cold heat exchange zones, then further cooling the intermediate pressure gas in several exchange zones by dividing into two streams. The first stream from the final exchange is expanded to yield partial liquefaction and the liquid is separated. The second stream is expanded to cool the gas and the two cold gas streams are used to cool at reduced pressure by exchanging with incoming helium. The high pressure cooled stream is likewise expanded and the cooled gas used in the intermediate pressure heat exchangers.

Pressure Generator for Liquefied Gas. C. H. May (assigned to H. L. Johnston, Inc.) U. S. 2,932,175 (1960) April 12.

A pressure pump for handling liquefied gases at low temperatures is claimed in which the pistons in two end pumping cylinders are driven by a central axially aligned third piston on a common rod. The central third piston is reciprocally moved by hydraulic fluid, which is passed cyclically through by an electrically driven pump with closely sealed valves. The pumping pistons act directly on the cold liquid gas to raise its pressure in outlet system. The heat of the hydraulic fluid is transferred to the outlet cold liquid by jackets.

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Acetylene

Acetylene Production from the Pyrolysis of Liquid Hydrocarbon Feedstocks. F. F. Braconier, P. J. Leroux, G. C. Grubb and W. W. Walk. Section IV-Paper 6. New York: Fifth World Petroleum Congress, 1959.

There has been a strong incentive to develop acetylene synthesis processes using as raw materials hydrocarbons heavier than methane, such as natural gasoline, naphthas, etc. This paper discusses the production of acetylene from liquid hydrocarbon feedstocks, using as illustration the SBA-Kellogg process, based on operations of the Societe Belge de L'Azote's demonstration unit in Belgium. Factors affecting acetylene concentrations and yields are illustrated by pilot plant data from the cracking of light naphtha. A schematic flowsheet is presented for the recovery and purification of acetylene. Operating costs of this process are compared with the ones obtained for the production of acetylene from methane and natural gas.

Fundamental Relationships in the Pyrolysis of Hydrocarbons to Acetylene and Ethylene. H. Krekeler, R. Wirtz and N. Pechtold. Section IV-Paper 5. New York: Fifth World Petroleum Congress, 1959.

Farbwerke Hoechst AG. has built a number of petrochemical plants in which hydrocarbons of different molecular weights are thermally cracked to lower-molecular-weight olefins. The influence of cracking temperature and feed stock composition on yield and composition of the end products has been studied in a high temperature pilot cracking unit. For a given feed material the composition and yield of product gas is dependent on the final reaction temperature attained. Results are independent of the temperature of combustion gases from the burner, provided this temperature is not higher than 2300°C, above which the C_2 content of product gas decreases. The energy input of the system is, however, strongly influenced by the burner gas temperature.

Carbon

Electrode Pitch. *Gas World 151,* Coking Supplement 51 (1960) April 2 (15 pp.)

Processes for electrolytic smelting of aluminum are outlined and the part played by pitch in aluminum furnace electrodes is described. The market for electrode pitch up to 1975 is considered. The properties required in electrode pitches and means for specifying them are reviewed. Modification of pitch properties is discussed and details are given of laboratory work on thermal treatment. The main principles for design of plant for thermal treatment of pitch, and effects of modifying coal carbonizing conditions are considered in detail in the article.

Catalysts

Rates of Adsorption of Hydrogen on Palladium and on Rhodium. M. J. D. Low. *Can. J. Chem. 38,* 588 (1960) April (8 pp.)

A study of the effects of temperature and initial gas pressure on the kinetics of chemisorption of hydrogen on alumina-supported palladium and rhodium catalysts revealed, for both gas-solid systems, that the adsorption proceeds through three kinetic stages. On increasing the temperatures from 0° to 400°C, the amounts of hydrogen adsorbed on both solids decrease. Over the temperature range the rates of adsorption on Pd decrease, while those on Rh increase, with increasing temperature. The general effect of increasing the initial gas pressure over the range 10-60 mm Hg is to increase both rates and extent of adsorption.

Coal Chemicals

Taking a New Look at Coal Chemicals. R. A. Labine. *Chem. Eng. 67,* 156 (1960) April 18 (4 pp.)

The Philadelphia & Reading Corp. and the Glen Alden Coal Co. announce new chemical complexes in the anthracite region. Also included is a short discussion of the coal gasification by Lurgi and the use of synthesis gas for chemicals or gasoline.

Fischer-Tropsch

Gasoline from Coal via the Synthol Process. L. W. Garrett, Jr. *Chem. Eng. Progress 56,* 39 (1960) April (5 pp.)

Gasoline production from coal via the Synthol process has been realized on a commercial scale at the South African Coal, Oil & Gas Corporation plant in the Union of South Africa. The basic plant has been built to process a sub-bituminous coal to make synthesis gas for the production of motor gasoline as well as a variety of oxygenated chemicals, a diesel oil, and several wax products. Facilities were also included to produce by-product phenol and ammonium sulfate from the gas liquor product of the coal gasification plant. The purpose of this article is to discuss those portions of the plant which are involved in the production of the primary motor gasoline and chemical fractions.

Fischer-Tropsch Synthesis Mechanism Studies. The Addition of Radioactive Ketene to the Synthesis Gas. G. Blyholder and P. H. Emmett. *J. Phys. Chem. 64,* 470 (1960) April (3 pp.)

When carbonyl labeled radioactive ketene is added to the extent of 0.7% of Fischer-Tropsch synthesis gas being passed over a singly promoted iron catalyst at 256°C and one atmosphere, the hydrocarbon products are found to have a small activity which is directly proportional to the number of carbon atoms in the molecule. Similar results are obtained when 0.50% ketene is added to synthesis gas passed over a cobalt catalyst at 189°C and one atmosphere. These results are interpreted as indicating that ketene dissociates on the surface so that only the methylene part of the molecule functions as the chain initiator.

Kinetics of the Fischer-Tropsch Synthesis on Iron Catalysts. Pressure Dependence and Selectivity of Nitrided Catalysts. F. S. Karn, J. F. Shultz and R. B. Anderson. *J. Phys. Chem. 64,* 446 (1960) April (6 pp.)

Variations of rate and selectivity of Fischer-Tropsch synthesis on nitrided fused iron catalysts as a function of operating conditions were studied. With $1H_2+1CO$ feed, the integral rate compared at constant conversion of H_2+CO was found to vary with the operating pressure to about the first power. At any given operating pressure, the differential reaction rate decreased more rapidly than the partial pressure of synthesis gas indicating that the rate is inhibited by reaction products. The relative usage of H_2 to CO decreased with increasing conversion, passed a minimum and then increased. The olefin content of C_2 and C_3 hydrocarbons decreased with conversion.

Synthetic Liquid Fuels by Fischer-Tropsch Process. J. H. Field, H. E. Benson and R. B. Anderson. *Chem. Eng. Progress 56,* 44 (1960) April (5 pp.)

This article summarizes recent commercial developments and the current status of the coal gasification, gas purification, and catalytic synthesis steps. Although interest in synthetic fuels processes has waned during the past decade because of unfavorable economics and new discoveries of oil, particularly in Canada and the Middle East, an appreciable amount of research has been continued and some commercial development has resulted. Catalyst research and bench-scale and pilot-plant studies have been continued at the Bureau of Mines.

Gasification

Gasification of Bone Anthracite. J. W. Eckerd, J. D. Clendenin, W. S. Sanner and R. E. Morgan. *U. S. Bur. Mines Rep. Invest. 5594* (Pittsburgh: The Bureau, 1960.)

This report describes an investigation of the technical feasibility of using a conventional commercial-size, rotating grate, dry-ash-removal type gas producer to make producer gas from chestnut-size bone anthracite. Test instruments were installed and some minor changes were made in the equipment to handle the large quantities of materials expected. Enough data were obtained to indicate that gas could be produced continuously and routinely from bone coal in this type of producer whenever conditions justified the necessary development work.

Oil Gas

Oil Gas Plant Bedford. K. B. Meggitt. *Gas World 151,* 608 (1960) April 16 (5 pp.)

To provide the additional gas requirements for the Cambridge division's integrated mains, it was decided to install a 2 million CF per day oil gas plant at the Bedford works. Since the oil gasification plant selected was of the regenerative type it was decided to convert two of the Lancashire boilers to oil firing with heavy oil, and the control room for the plant was situated so that one operator would be able to look after the plant. Operating results and plant practice on different oils are discussed.

Ore Reduction

H-Iron Production by Alan Wood. R. A. Lubker and K. W. Bruland. *J. Metals 12,* 321 (1960) April (4 pp.)

The Alan Wood Steel Co.'s iron powder plant is composed of 4 interrelated sections: iron ores are prepared for reduction in the raw material section; hydrogen, the reducing agent, is processed from coke-oven gas and oxygen; the ore and hydrogen are chemically reacted in the H-iron reduction section to produce metallic iron; the metallic iron is then further processed in the finishing plant. The high operating pressure, which is the principal departure from other fluidizing processes, permits a high rate of reduction at low temperatures.

Nu-Iron, a Fluidized-Bed Reduction Process. T. F. Reed, J. C. Agarwal and E. H. Shipley. *J. Metals 12,* 317 (1960) April (4 pp.) **Nu-Iron: Good Process, but . . .** *Chem. Eng. 67,* 64 (1960) April 4 (4 pp.)

To obtain design and development information on the Nu-Iron process, U. S. Steel Corp. built and operated a pilot plant at the ore-treating laboratory. In the pilot plant, make-up gas is produced in a tube-type reforming furnace by reacting natural gas (desulfurized with activated charcoal) with steam in the presence of a catalyst at 1600° to 1800°F. The hot, reformed gas contains H_2, CO, CO_2, and H_2O. The CO in the reformed gas is converted to CO_2 in a water-gas-reaction shift converter by reacting the CO with steam in the presence of a catalyst at 600° to 800°F. The gas leaving the converter is cooled to remove water, then compressed to 60 psig and scrubbed in an adsorption column to remove CO_2. The fresh make-up gas is mixed with recycle gas and is now called reducing gas. This gas passes upward to the ore-reduction system, fluidizing and reacting with the solids in each bed.

Self-Agglomerating Fluidized-Bed Reduction. B. G. Langston and F. M. Stephens, Jr. *J. Metals 12,* 312 (1960) April (5 pp.)

To permit utilization of low-grade iron-ore requires the development of an efficient system to beneficiate the ore to a grade sufficiently high for the concentrates to be used economically. Thus, if equipment could be designed to take advantage of the fine particle size and, at the same time, directly convert large tonnages of the concentrates to metallic iron in relatively small units, an improvement might be made in the production of iron. Data obtained on the direct reduction of finely-ground iron concentrates with hydrogen has demonstrated a mechanism which utilizes the adhesive characteristics of the particles in a fluidized bed for the production of agglomerated particles of a controlled size.

The Use of Fluidization for the Reduction of Iron Ores with Gas Containing CO and H_2. J. Willems. *Rivista dei Combustibili 14,* 118 (1960) Feb. (18 pp. Italian text.)

A series of tests to investigate the technical and economic prospects of reducing iron ores in the fluidized state is described. The pulverized ore is placed upon a grid or perforated plate and a stream of gas with a high H_2 or CO content, travelling upward, lifts the powder and keeps it in suspension, reducing the iron oxides to metal. The process is performed at various temperatures from 500° to 900°C. The results achieved so far indicate prospects for an industrial application of the process.

Pyrolysis

The Kinetics of Pyrolysis of Ethane and Related Hydrocarbons. H. G. Davis and K. D. Williamson, Section IV-Paper 4. New York: Fifth World Petroleum Congress, 1959.

Methane was shown to be formed from ethane by a first order reaction with activation energy about 86 kg-cal. The reaction is not inhibited by propylene and should correspond to the primary rupture of the carbon-carbon bond in ethane to form methyl radicals. With this assumed, rate constants were estimated for methyl formation and recombination. Measurements of the rate of appearance of propane and butane allow an estimate of the concentration of methyl and ethyl radicals under particular conditions and make estimates of the specific rates of some free radical reactions possible. The combination of ethyl radicals to form butane is a major chain ending step in the range of conditions studied.

Reformed Gas

Endothermic Catalytic Cracking of Natural Gas and Refinery Gas. G. Hellendoorn, J. H. Baars and E. de Jong. *Rivista dei Combustibili 14,* 136 (1960) Feb. (13 pp. Italian text.)

From previous results of industrial scale tests on catalytic endothermal reforming, the authors present now further details on the following subjects: heat balance for natural gas reforming; converting refinery gases by cyclic catalytic process; analysis of the composition of hydrocarbons before they enter the catalytic bed.

Sulfur Oxides

Bench-Scale Investigation on Removing Sulfur Dioxide from Flue Gases. D. Bienstock and F. J. Field. *J. Air Pollution Control Assoc. 10,* 121 (1960) April (5 pp.)

An extensive screening program was undertaken for testing solids as potential absorbents, adsorbents and oxidation catalysts for removing sulfur dioxide. A schematic diagram of the bench-scale unit shows the reactor containing a fixed bed of the solid under test and the blending system for preparing a simulated flue gas. Most of the common metallic oxides were prepared and tested as absorbents. In addition to their use as absorbents

their value as oxidation catalysts was studied. Several activated carbons some impregnated with metallic oxides as well as molecular sieves were tested. The results of these tests are tabulated and discussed.

Underground Gasification

Simulated Underground Gasification of Coal and Electrolinking-Carbonization Method of Preparing Path in a Coalbed. M. W. Wilson, L. L. Hirst, J. L. Elder, J. P. Capp and J. J. Gentile. *U. S. Bur. Mines Rep. Invest. 5605* (Pittsburgh: The Bureau, 1960.)

Laboratory experiments simulating underground gasification of coal were conducted to study the process and to determine the characteristics of a coalbed during gasification. Experiments were also made to investigate the properties of coal and other factors affecting the electrolinking-carbonization method of preparing a path through a coalbed before gasification. Oxygen in the combustion air reacted with the first hot carbon contacted, resulting in maximum coal utilization at air-inlet ports. Electrolinking of bituminous coal parallel to bedding planes usually carbonized the coal in a straight line path, whereas electrolinking across the bedding planes produced an erratic path. Electrical resistance measurements of coal varied over a wide range.

Water Gas

The Effect of Light Distillates on Carbureted Water Gas Production. J. V. Craddock and R. W. Hind. *Gas J. 302,* 20 (1960) April 6 (5 pp.)

A light petroleum distillate has become available as a result of the changing pattern of demand for the products of the oil refineries now established in Britain. This surplus fraction is known by a variety of names; primary flash distillate or as Shell Refining Co. refer to it as L.D.F. 170 contains 96.5% of paraffin hydrocarbon. The primary flash distillate may be used for enriching blue water gas by cracking in the carburetor in the normal manner. It can, in addition, be reformed by passing the vapor through the fuel bed during the normal back-run of the cycle. When reforming, the thermal yields from the raw materials cannot be calculated by the accepted water gas formulas. This paper is concerned only with two methods of reforming: thermal cracking and steam reforming.

Ethylene

Production of Ethylene. W. R. Nisbet and W. H. Agee (assigned to Monsanto Chemical Co.) U. S. 2,928,886 (1960) March 15.

In a continuous pyrolytic process for converting hydrocarbon stocks to gaseous olefin products, improved quenching of product gases is claimed in which a cool oil-in-water emulsion is contacted with the gases in a quenching zone, said emulsion containing 5-40% of aromatic oil with a high heat of vaporization.

Gasification

Apparatus for the Gasification of Solid Fuels. D. B. Eastman (assigned to Texaco Inc.) U. S. 2,931,715 (1960) April 5.

Apparatus for gasification of powdered coal is claimed which comprises a vertical pressure vessel with reactor and reactant inlets in upper shell, gas outlet port midway in lower wall of shell, a body of water maintained in lower shell, and an internal water jacket in lining of shell surrounding reactor chamber and extending below lower water level. A second pressure vessel with water in its base is connected from the first vessel's is gas outlet port by a water jacketed dip-pipe with water supply circulated to the second vessel, transfer line and to the reactor jacket by equalized pressure connections to provide product quenching and slag cooling in the lower water zones.

Ore Reduction

Beneficiation of Low-Grade Hematitic Ore Materials. F. D. DeVaney (assigned to Pickands Mather & Co.) U. S. 2,931,720 (1960) April 5.

Cyclic process is claimed for roasting of iron ores to convert the ore to magnetite. It comprises a shaft containing a descending column of the finely-ground particulate ore fed from a bell charger seal. A reactive gas mixture at room temperature comprising CO_2, CO, H_2 and inerts is injected at the base of the shaft, cooling the reduced product and becoming heated by transfer from hot ore. Reduction is achieved by this countercurrent flow of reducing gas. The bulk of the heat is supplied by combustion of oil or gas to CO_2 in the side chamber to form combustion gases at 1700°-1800°F, blending with clean spent gas from the ore shaft and injecting this hot gas at intermediate shaft level at a rate to raise the ore to 800°-1700°F in the upper shaft. Gases are introduced through louvered "breaker" pipes placed crosswise of the shaft, and the ore column may be loosened above the breakers by paddles on rotating stirring shafts driven from outside of the shaft. Product is cooled and withdrawn from a basal gas-lock.

Iron Ore Reduction Process. F. W. Luerssen (assigned to Inland Steel Co.) U. S. 2,928,730 (1960) March 15.

In an iron ore reduction process using a hot CO-rich reducing gas obtained by burning solid carbon, an improvement is claimed whereby the entrained ash is removed from the gas by cooling it in a heat exchanger, scrubbing out or precipitating the ash and reheating the cleaned gas to 900°-1800°F before returning it to the reducing vessel.

Method and Apparatus for Handling Gases in a Direct Reduction Process. J. C. Agarwal, F. Kraus and T. R. Roszkowski (assigned to U. S. Steel Corp. and The Lummus Co.) U. S. 2,929,703 (1960) March 22.

In an iron oxide fines reduction process using hydrogen and CO, the off-gases from the reactors are regenerated by passing them through three heat exchangers in series, in which the first one heats the fresh reactant gas and the second and third are heating the returning scrubbed and cooled regenerated gases. Cooling by refrigerated water is used to remove last traces of reaction moisture before the reacted gases are mixed with fresh gas, then reheated and recycled to the reactor.

8. GAS DISTRIBUTION

Distribution Systems

Operation of Grid Systems in the East Midlands Area. C. E. Mills, A. W. Elliot and G. H. Potter. *Gas J. 301,* 511 (1960) March 30 (5 pp.)

Due to the base load nature of the coke oven gas supply, the incidence of the 5-day large industrial load, mainly in the northern production region, where little or no industrial gas is required at weekends, gasholders probably perform a more important function in this Board than in any other. The gas made during the weekend must be stored for use during the week, and a 5 million CF capacity gasholder can be equivalent to a manufacturing plant of a capacity of 1 million CF per day. Economic operations depend on an annual production forecast based on assumed average temperature conditions adjusted for any known trends. The program is reviewed monthly and adjustments made for unforeseen conditions, either in plant availability or output trend.

Leakage

The Laboratory in Utility Gas Leak Detection. I. Deutsch. *Gas 36,* 64 (1960) May (5 pp.)

Analysis of gas samples from the field makes it possible to distinguish between utility gas and other gases commonly found in soil. The chromatographic principle of separating components in conjunction with a platinum element combustible gas detector makes it possible to analyze for methane and ethane components in highly dilute samples, e.g. ¼ per cent natural gas in air, at minimum capital outlay and minimum skill.

Sonic Leak Detector. D. J. Manning. Paper DMC-60-29. (New York: American Gas Association, 1960, $.25.)

The Electronic Leak Finder (ELF) is considered to be an additional and supplemental method of leak detection rather than a replacement for any tried and satisfactory method now in use. The detector is used where services have been cleaned, particularly by augering; it will determine whether or not the work on the service has caused it to leak. After a leak has been repaired in an area where the ground is porous, the Finder will indicate whether or not another leak exists. Without the detector, considerable time must elapse in many cases before venting of the ground progresses to the point where this can be determined.

Mains

Uprate or Not? A Planning Approach to Raising Pressures in Existing Mains. J. L. Davidson. Paper DMC-60-18. (New York: American Gas Association, 1960, $.25.)

Outline is presented of a planned approach to elevating pressures with the intent of stimulating study to a point where application of higher pressures will be considered as acceptable alternates in providing for load growth. An economic comparison of alternative methods is suggested. An example of uprating a steel main in Long Island is given. A suggested check list of factors to be considered in a study of raising pressures is appended.

Metering

Bibliography of Gas Meters and Metering. F. Peters. Paper DMC-60-22. (New York: American Gas Association, 1960, $.25.)

Periodic revision of the *Bibliography of Gas Meters and Metering* is an established project of the Metering Subcommittee. Interim supplements are prepared as the volume of published material justifies. The first revision was completed in 1950. At that time the subcommittee recognized the need for a regular revision schedule. Subsequent supplements were released in 1952 and a second revision was completed in 1955. Mimeographed supplements were released in 1957 and 1959.

Residential Meter Survey. C. A. Gallagher. *Gas Age 125,* 21 (1960) April 28 (20 pp.)

Author discusses pros and cons of outdoor meters, including outdoor temperature effect, amount of damage from tampering, appearance in front of residence and convenience to the customer. Information from 152 questionnaires sent to utilities in the United States and Canada are included. These data indicate that customer acceptance of outside sets is satisfactory and savings can be realized through outside installations in dry natural gas areas.

What's New in Rotary Metering. R. R. Newquist. Paper DMC-60-15. (New York: American Gas Association, 1960, $.25.)

Roots-Connersville in recent years has had an ambitious program of research and development in rotary product lines. The need for improving the appearance of existing rotary meter lines and the addition of certain types and sizes was pointed up by two different market studies made in the gas industry. In addition to broadening the area of application for rotary meters, both capacity and pressures, with new sizes and designs, there are many improvements being incorporated in rotary meters in general. Improved design, better machining techniques, standardization of parts and more rigid inspection, will insure accurate measurement, minimum maintenance and long life.

Peak Loads

Calculation of Gas Flow with Changing Loads. M. F. R. de Brem and M. A. Gouffee. *Compt. Rend. Congr. Ind. Gaz 76e* Congr. Paris, 511 (1959) June (18 pp. French text.)

The calculation of gas flow in a distribution system with varying loads is determined by a set of equations which cannot be solved by classical, mathematical methods. The author investigates three new solution procedures. The first method is a mathematical approximation which is justified in most cases. The second, based on the same approximation, makes use of an analog computer; and the third uses a digital or analog computer to furnish the solution. A comparison of the agreement of results of each method is illustrated with two examples.

Fluctuations in Gas Output. M. G. Nahon and M. H. C. Taburet. *Compt. Rend. Congr. Ind. Gaz 76e Congr.* Paris, 657 (1959) June (26 pp. French text.)

The characteristics of gas demand fluctuations, the importance of the effects of gas consumption for space-heating to the seasonal fluctuations and the statistical methods used to predict peak demand are summarized. A comparison of experimental data with theoretical utilization coefficients proves that the latter can be used for forecasting peak loads.

Measuring Peak Load through District Regulating Stations. W. F. Redd, Jr. Paper DMC-60-19. (New York: American Gas Association, 1960, $.25.)

Three means of measurement that have been applied to district regulators with some degree of success are outlined and illustrated. The first is the use of an orifice meter in the supply line piping. Another approach to the physical measurement of the gas through the district station is the use of a pitot tube meter. The last method determines the flow through the regulator by means of positioning the regulator valve. There are also a number of patented devices on the market that will give the desired results. Several of these record gas velocities and several measure quantities. A limited investigation of these devices indicates that they are rather expensive.

Peak Shaving

Distribution Peak Shaving Problem as Related to Winter Gas Loads. G. W. Warrick. *Gas Age 125,* 20 (1960) May 12 (5 pp.)

Competition for the space-heating load is becoming sharper each year. The need to supply this load economically is becoming more important. In the northern U. S., the difference in magnitude between summer and winter gas needs obviously enters into the economics of space heating. The author describes methods of determining the relationship of winter temperatures and gas send-out to find out how much extra fuel is needed for peak service.

Services

Casings, Casing Spacers, Casing End Seals All Sizes, Including Service Entrance Casings. A. H. Hokanson. Paper DMC-60-9. (New York: American Gas Association, 1960, $.25.)

Results of a questionnaire sent to representative U. S. gas companies are discussed. Only one third of the companies cathodically protected the casings, and this was usually by coating and/or wrapping. About 95% stated that their companies used a commercial type spacer; 40% also reported use of other than commercial casing spacers. Of the respondent companies 90% use commercial type end seals and 30% reported they use other than commercial casing end seals. About 60% of the companies use service entrance casings when going through masonry foundations and 16% use commercially available service entrance casings.

Plastic Tubing Used in 16% of New Service Installations in Denver. *Gas Age 125,* 45 (1960) April 28.

Originally used as an insert replacement for corroded metal pipe, butyrate tubing is now used in 16% of new gas service installations by Public Service Co. of Colorado. The tubing is transparent enough to permit a visual inspection for flaws or foreign particles. Among its other advantages, the plastic pipe can be laid directly in the ground without the use of protective casings, and its flexibility allows small changes in curvature without the need for fittings.

9. GAS FUEL UTILIZATION AND APPLIANCES

Air Pollution

Effects of Design and Fuel Moisture on Incinerator Effluents. R. L. Stenburg, R. R. Horsley, R. A. Herrick and A. H. Rose, Jr. *J. Air Pollution Control Assoc. 10,* 114 (1960) April (7 pp.)

This report covers the second phase of a study directed towards development of incinerator design standards and criteria for minimizing discharge of atmospheric pollutants from multiple chamber incinerators. Tests were made to determine the effects of fuel moisture content on pollutant emissions from an experimental incinerator of fixed dimensions while varying the amount and distribution of combustion air and the burning rate as measured by the amount of fuel charged per hour. (For first phase of study, see *Gas Abstracts 15,* 78).

Burners

Minimizing Lint Stoppage of Atmospheric Gas Burner Ports. E. J. Weber. Research Bulletin 79. Project DA-8-GU. New York: American Gas Association, 1960, $2.50.

The investigation demonstrates that the time interval between port cleanings of a burner in a linting atmosphere can be prolonged by proper burner design and adjustment of port loading and primary aeration. Relationships are developed for the correlation of the effect of port blockage on primary air injection as a function of port loading and initial primary aeration as well as the fall-off of primary air injection with time for burners exposed to a given linting condition. The build-up of port blockage with time as a function of port loading and initial primary aeration is also discussed.

Gas Company Experiences with the Experimental High Performance Burner. F. G. Hammaker. Research Bulletin 80. Project DA-3-C. New York: American Gas Association, 1960, $2.00.

Based on study and tests by utilization, servicing and home service departments of eight utility companies, it appears that the newly developed experimental high performance burner as adapted to conventional ranges is considered to have an attractive appearance, easy cleanability and easy removal for servicing. It was reported to have good performance as a single-duty burner for low, medium and high temperature operations. Exceptions were attributed to improper burner adjustment.

Combustion

Surface Effects in Butane Oxidation. M. Cherneskey and J. Bardwell. *Can. J. Chem. 38,* 482 (1960) April (11 pp.)

The oxidation of butane is considerably affected by the nature of the vessel surface. With a silica vessel, vigorous combustion accompanied by multiple cool flames occurs between 280°C and 320°C. These reactions are strongly inhibited when the vessel walls are coated with metal oxides or metal halides. Higher pressures are required for ignition at all temperatures. Of the compounds studied, lead monoxide is the most effective inhibitor. The results suggest that in the antiknock action of lead tetraethyl the true inhibitor is lead monoxide.

Thermocatalytic Combustion: Heat without Flame. G. Weiss. *Ind. Research 2,* 24 (1960) April-May (5 pp.)

This article presents a discussion on the development of "thermocatalytic combustion" which is destined to revolutionize heating. The nucleus of the system is a thermocatalytic reactor, called "Pyrocore". A typical Pyrocore reactor of 30,000 Btu/hr output, operating on any gaseous or liquid fuel is a cylinder about a foot long and an inch in diameter. In operation it resembles a yellow fluorescent tube. A mixture of air and gaseous fuel is introduced into the open end under slight pressure and forced through the pores. Since the reaction takes place on the outer surface of the reactor, the combined effects of both radiant and convection outputs are available.

Flame Research

The Origin of the Blue Continuum in the Hydrogen Flame. P. J. Padley. *Trans. Faraday Soc. 56,* 449 (1960) April (6 pp.)

Results of application of flame-photometric techniques developed by Sugden and co-workers for the quantitative measurement of concentrations of hydrogen atoms and hydroxyl radicals in flame gases strongly suggest the origin of the hydrogen flame continuum to lie in the radiative association $H + OH \rightarrow H_2O + h\nu$.

Propagation of Flames Supported by a Zeroeth-Order Chemical Reaction. J. O. Hirschfelder and S. S. Van Domelen. *Phys. Fluids 3,* 210 (1960) March-April (7 pp.)

Flames supported by zeroeth-order chemical reacions have two very useful, unique properties. Their characteristics are independent of diffusion, and the chemical reactions are completed at a finite point in space. These properties should make zeroeth-order flames ideally suited to serve as "global" reactions for complicated flame systems involving either three-dimensional geometry or time dependent phenomena. Extensive tables are given for the properties of steady-state one-dimensional zeroeth-order flames.

Relations of Fundamental Flashback Blowoff and Yellow-Tip Limits of Fuel Gas-Air Mixtures to Design Factors of Burners in Gas Appliances. J. Grumer, M. E. Harris and V. R. Rowe. Project PDC-3-GU. (New York: American Gas Association, 1960, $2.00.)

Multiport burners manifested the fundamental limits of the mixture being burned, but the flow characteristics into and through short flame ports connected to a common manifold were more complex than realized. These differences were attributed to two things: the flow through multiports "resonated" slightly and adjacent flames interacted with one another. Ambient flows of inert gas around the flame base virtually eliminate stable rich flames. Flashback limits are not affected by ambient flows of inert gas around the flame port. Flashback and blowoff limits are inverse functions of ambient pressure.

Heat Pump

Wichita School Heat Pump. C. E. Wagner. *Air Conditioning, Heating and Ventilating 57,* 72 (1960) April (3 pp.)

The rural high school in Wichita, Kansas is located over an unlimited underground water supply referred to as the Underground Arkansas River. By using this 60°F water as a heat source, the engineers found that a water-to-water heat pump could be economically utilized to provide both heating and air conditioning for the project. Studies showed the coefficient of performance for heating with the heat pump to be 3.85 and revealed the following annual comparative fuel costs: $7,600 for natural gas based on heat loss of 8,500,000 Btu/hr and $6,940 for electricity using the heat pump.

Incinerators

How Gas Incineration Cuts Air Pollution. R. Goder and D. A. Watkins. *Ind. Gas* (American) *38,* 5 (1960) April (4 pp.)

Combustible refuse from commercial establishments can be estimated at 1¼ lb per person per day or in a city of one million people, this would mean 1,250,000 lb per day that should be destroyed "on the spot" instead of being stored, hauled and dumped. The proper selection and installation of incinerators for a given amount of waste in various places of application are outlined.

Industrial Heating

Automatic Brazing of Tank Assemblies for Automobile Heaters. P. Crespy. *Ind. Heating 27,* 752 (1960) April (4 pp.)

Soldering a top tank assembly for the heater core has been solved through the use of an automatic gas-fired silver brazing machine designed and manufactured by Selas Corp. of America. Taking up floor space of only 5 by 5 ft, the machine is producing, with one man operation, what formerly required five men and much more floor space.

Cincinnati Industries Use Gas for Many Purposes. A. Q. Smith. *Ind. Gas* (American) *38,* 7 (1960) April (7 pp.)

Among the nearly one thousand industrial gas customers served by the Cincinnati Gas Electric Co., this article is concerned with a few representative ones utilizing natural gas for a variety of processing operations. Operations where gas is utilized are aluminum castings, match plates, cans, greeting cards, black-top road paving, instant coffee and automobile transmissions.

Harrogate Gas at Work in Industry Exhibition. E. Ford. *Gas J. 302,* 108 (1960) April 6 (9 pp.); **Gas at Work in Industry at Harrogate.** *Gas World 151,* (Industrial and Commercial Gas 41, 68) (1960) April 16 (4 pp.)

A clear indication of the ubiquitous applications of gas in the north was seen at the Gas at Work in Industry Exhibition which was held at Harrogate from March 28 to April 1. Organized by the North Eastern and Northern Gas Boards, this was an entirely new event and the first of its kind to be held outside London. The exhibition had been extended in its scope and sections were devoted to research and development carried out in the following fields: heat treating, stress-relieving, salt baths, crucible furnace, foundry applications, textile drying and treating, metal hardening and cutting, air heating, incinerating, water and space heating.

Radiant Burners Inside Rolls Assure Uniform Asphalt Coating. B. R. Politica. *Ind. Gas* (American) *38,* 3 (1960) April (2 pp.)

The improved coating process tailored for production of the Johns-Manville's Roofinsul and Weathertite boards, is centered around the use of three pairs of steel calendar rolls. The Gradiation heating system in the ceramic cylinders within the rolls, which were designed and built by Selas Corp. has eliminated the troublesome "hot-spot" problem encountered in coating and strike-in operations of this type. Sheathing board processed between the uniformly heated steel rolls comes off the production line without a trace of black residue left on the surface.

Inert Gases

Controlled Furnace Atmosphere in Heat Treatment of Steel. A. L. Forrester. *Gas World 151,* (Industrial and Commercial Gas 41, 73) (1960) April 16 (4 pp.)

Comparatively new uses of town gas for production of controlled furnace atmospheres have achieved improved heat treatment conditions. It is produced in a generating unit, consisting of a combustion chamber, one or several burners and mixing equipment for gas and air for combustion. Of the fuels used, town gas is one of the most economical and easily controllable. The Holmes-Kemp inert gas generator and the Alnor dewpoint apparatus are discussed.

Ovens

High Speed Oven Design and Baking Studies. T. E. Hampel. Part 1. Research Bulletin 81. Project IA-9. New York: American Gas Association, 1960, $2.00.

This bulletin describes progress in studying gas-fired portable deck bake oven design from the viewpoint of provision of proper oven environment for a selected group of food products. An experimental deck bake oven was designed and constructed to furnish almost every conceivable combination of baking chamber atmosphere heating methods and hearth heating methods. Full deckloads of twelve of the thirteen products were baked satisfactorily in the experimental oven.

Space Heating

Infra-Red Heaters Solve Difficult Heating Problems. *LP-Gas 20,* 22 (1960) April (2 pp.)

Difficult heating problems presented by high factory ceilings are a thing of the past when LP-gas fired infrared heating systems are used. The ceilings of the Solem Machine Company's Rockford, Illinois plant are 28 feet high over most of the building area and a monitor runs 50 feet above the floor. Studies made during the first winter showed not only a payoff in worker comfort but also a fuel cost saving.

Refrigeration

Jet Refrigeration System. M. Dubitzky (assigned to The Coleman Co., Inc.) U. S. 2,931,190 (1960) April 5.

Refrigeration system employing jet pumps in a heat-operated cycle is claimed. This comprises evaporating the refrigerant (water) to provide refrigeration, passing it through heat exchangers and boiler, compressing it by a jet pump operating with a cyclic fluorocarbon ether as motive fluid, with the two fluids mixing and passing through heat exchangers, condenser and gravity separator. The fluorocarbon is chosen for its high specific heat in the vapor phase.

10. EQUIPMENT AND INSTRUMENTATION

Absorbers

Absorber Design Now Simplified. S. H. Landes and F. W. Bell. *Oil Gas J. 58,* 94 (1960) May 2 (5 pp.)

The graphical method of absorber design presented in this article hits a happy medium between a rigorous plate calculation and the shortest empirical method. The inexperienced or part time absorption calculator should be able to design safely by this method. This type of design has been applied successfully to both high and low-pressure absorbers, normal and subzero temperature absorbers, and reabsorbers for recovery of ethane and heavier hydrocarbons.

Air Pollution

Improved Smoke Density Recorder. R. Lambie. *J. Sci. Instruments 37,* 144 (1960) April (3 pp.)

A smoke density recorder is described in which high stability is achieved by the use of stabilized circuits for the light source and head amplifier. A method of calibration by means of optical density screens standardized for the type of photocell used is given. Drift caused by deposition of smoke on the optical system was overcome by the use of hot air jets. During extended tests on laboratory and industrial installations, stable operation with negligible drift was obtained.

Automation

Electronics in the Gas Industry. M. Needham and J. H. Whitaker, Part 1. *Gas J. 301,* 470 (1960) March 23 (3 pp.); Part 2. *Ibid.,* 506 (1960) March 30 (5 pp.)

The first part of this paper deals with various methods of

measurement and control by electronic instruments with a certain amount of elementary computing. Part two traces down the origin of the presently used equipment and describes this powerful tool in terms of industrial application. The sheer volume of engineering and design effort needed to prepare a generating station or a gasworks for automatic start, stop and control is such that considerable time must elapse before it can be studied, evaluated and built into safe reliable control gear. A step by step program for station automation is given as a summary.

Coal Handling

Pressurization of Granular Solid Fuels. M. N. Aref. *J. Eng. Power 82,* 156 (1960) April (12 pp.)

The different methods of pressurizing powdered solid fuels which have been developed are reviewed briefly, including proposals as well as those in operation. The work has been devoted particularly to a study of the characteristics of these pressurizers, in relation to their common problems of: power loss due to venting the pressurizing air, wear of the surfaces in contact with the solids, and effective sealing.

Computers

Machine Computations for Transient Stagewise Processes. D. Yesberg and A. I. Johnson. *Can. J. Chem. Eng. 38,* 49 (1960) April (6 pp.)

A review of recent work on transient stagewise mass transfer processes is presented, with particular emphasis on numerical and analog solutions for the partial differential difference equations involved. An example of gas absorption is considered in which the equations are linearized, and solved numerically as well as by the use of a resistance network analog. These particular methods of solution had not previously been used for this problem, and the present work is compared with previous solutions. The novel feature of the method of the solution is the representation of the time derivative by a backward finite difference to produce a set of simultaneous algebraic equations, which may be solved most easily by matrix inversion programed on a digital computer.

Gas Turbines

Bureau of Mines Coal-Fired Gas Turbine Research Project. J. P. McGee and R. C. Corey. *Combustion 31,* 67 (1960) April (6 pp.)

Development of a coal-fired open-cycle gas turbine will depend largely on basic and applied research directed toward minimizing the erosive and corrosive effects of the mineral matter in the coal. The principal research efforts must be conducted to determine the optimum geometry of the blades and gas passages, the best design of the combustor and burners for maximum combustion efficiency and permissible concentration and size of the particulate matter in the gases entering the turbine. The Bureau's program considers numerous variables such as the optimum coal fineness, dust-collector efficiency, and so forth and includes it in the overall program.

High Temperatures

The Plasma Jet in Chemical Synthesis. C. S. Stokes and W. W. Knipe. *Ind. Eng. Chem. 52,* 287 (1960) April (2 pp.)

New methods for making high temperature materials as well as endothermic compounds are constantly sought. The plasma jet may be used to produce such materials. Titanium and magnesium nitrides, nitrogen tetroxide, and cyanogen were synthesized using a nitrogen plasma jet. This new method of preparation has opened a new field for investigation i.e., the use of very high temperatures to synthesize chemical compounds.

The Plasma Jet in High Temperature Research. S. Katz, E. J. Latos and E. Raisen. *Ind. Eng. Chem. 52,* 289 (1960) April (2 pp.)

The plasma jet provides a relatively simple means of producing a sustained flow of supersonic, extremely high-temperature gas. A new, refined plasma jet permits unobstructed observation of the arc process through a glass chamber. The ionization of monatomic and diatomic stabilizing gases in the process occurs in successive stages. Properties of the plasma were studied and are comparable with those of a flame. The plasma jet is used to simulate conditions associated with hypersonic flight and also can be used to obtain data on high temperature processes. It should be possible to measure temperatures and chemical, thermodynamic and kinetic phenomena by means of the plasma jet.

Process Control

What is Linear Programing? J. E. Chenevey. Part 1. *Oil Gas J. 58,* 113 (1960) March 7 (6 pp.); Part 2. *Ibid.,* 108 (1960) March 21 (3 pp.); Part 3. *Ibid.,* 114 (1960) April 4 (4 pp.)

Author illustrates linear programing by discussing problem formulation and solution in nonmathematical terms. Part 2. Shows a linear-programing-solution technique in detail easily to be followed with ordinary algebra. The last part of the series applied this technique to a study of a complete refinery.

Temperature Measurement

The Behaviour of the Venturi Pneumatic Pyrometer in Industrial Furnaces. R. E. Holland, R. Jackson, and G. G. Thurlow. *J. Inst. Fuel 33,* 180 (1960) April (9 pp.)

The design and principles of the venturi pneumatic pyrometer are briefly described, and a discussion of the experiences obtained in using the instrument in a number of industrial appliances follows. These include the open-hearth furnace, the Bessemer converter, glass tanks, oil and pulverized-fuel-fired water-tube boilers. Finally, tests carried out in the experimental pulverized-fuel-fired furnace at the International Flame Research Station, IJmuiden, are described in which the pneumatic pyrometer was used in conjunction with a suction pyrometer in an attempt to get preliminary data on the differences between particle and gas temperatures in pulverized fuel flames. These experiences demonstrate the advantages of the venturi pneumatic pyrometer, especially when compared with the suction pyrometer, in

that it is equally accurate at all temperatures, has a rapid response, blocks only slowly in dirty gases and, even when the inevitable deposits form, is easily cleaned.

Temperature Measurement and Control. 1. Thermocouples. E. W. Jackson. *Chem. Process Eng. 41,* 139 (1960) April (4 pp.)

This article gives the historical development of thermocouples and endeavours to put foreward some equations representing the approximate relationship between temperature and e.m.f. Various methods of measuring e.m.f. as well as ways of compensating for variations of cold junction temperature are described. A selection of metals that can be used together with their temperature limitations is given. It is of interest to note, that recently new combinations of metals have extended the range of temperature measurement by thermocouples to 2800°C. This review therefore is of interest to those wishing to gain further information about the rapidly growing techniques of temperature measurement and control.

Temperature Measurement and Control. 2. Temperature Control Data Logging Equipment. W. J. A. Donnelly. *Chem. Process Eng. 41,* 144 (1960) April (3 pp.)

The Sunvic equipment described here provides temperature monitoring and data logging for a continuous chemical process plant of Imperial Chemical Industries Ltd. Hundred of thermocouples throughout the plant are sampled every 15 minutes by a monitoring system which can print out both a half-hourly log and an off-normal abstract while giving alarm signals where necessary. The operating principle is based on self-balancing potentiometers, equipped for digitising, and extensive testing facilities are provided.

Ultrasonics

Ultra- and Hyper-Sonics. W. P. Mason. *Ind. Research 2,* 30 (1960) April-May (5 pp.)

Today, high-amplitude ultrasonic waves disperse fog and clean air of dust particles. Ultrasonic cavitation boils away contaminants from parts being cleaned, breaks polymer chains, sterilizes milk, and produces new alloys and more uniform, smaller grain sizes in castings. Ultrasonic drilling, welding and soldering are developing rapidly. In the lower power range, besides sonar uses, the propagation of sound waves are used in pulse-decoding systems, information storage for computers, and inspecting materials and parts for flaws. Current military applications include moving target indicator sonar systems and mechanical filters for radio and communication. The principle and application of ultrasonics are outlined.

Fluid Flow

Transducers for Acoustic Flowmeter. J. Kritz. U. S. 2,931,223 (1960) April 5.

An acoustic flowmeter using transducers is claimed for measuring the velocity of a fluid. In this device, one transmitting and receiving set of transducers transmits downstream of the flow and a second set transmits upstream over substantially equal paths. Improvement comprises means of focusing acoustic waves on the opposite receiver.

11. MATERIALS OF CONSTRUCTION AND CORROSION

Cathodic Protection

Cathodic Protection. Review of Marine Applications. P. H. Hopwood. *Corrosion Tech. 7,* 118 (1960) April (3 pp.)

Protection of tanker's cargo/ballast tanks by cathodic protection was introduced in 1952 using magnesium anodes. Its success led to the protection of immersed hull areas and now all water ballast spaces in all types of vessels can be so protected. Considerable thought has to be given to reduction of installation costs in tanker compartments and to anode safety. Topics particularly discussed here are: coating limitations, galvanic external protection, cathodic protection and fouling and use of impressed current.

Deep Ground Beds for Cathodic Potection. S. E. Trouard and E. A. Wagner, Jr. Paper DMC-60-1. (New York: American Gas Association, 1960, $.25.)

Advantages of deep ground beds may be summarized as follows: full rectifier capacity is available for protection of structure to be cathodically protected; lower power costs because of drastically reduced ground bed to earth resistance; smaller space is required; they can be installed at any convenient location; cost of cathodic protection coordination tests is practically eliminated since current pickup on foreign lines is negligible.

Coatings

Extruded Type Plastic Pipe Coating. J. V. Adkin, O. E. Moore and J. C. Vogt. Paper DMC-60-5. (New York: American Gas Association, 1960, $.25.)

Extrusion of a plastic polyethylene film on pipe is a relatively new process. Purpose of this paper is to collect experiences of some users of this new product, compile the information and present it to the gas industry for its information. A copy of the questionnaire used in obtaining this information is appended.

Corrosion

Deterioration of Gasholders. Cause and Electrochemical Remedies. K. G. C. Berkeley. *Corrosion Tech. 7,* 111 (1960) April (3 pp.)

Severe wastage of steel generally found to occur in gasworks can be attributed to the presence of the usual conditions which enhance electrochemical corrosion. Any steelwork in such a location may be exposed to soil, air or water, and any of these or a combination of them can produce severely corrosive conditions which, in a short time, will have drastic results. Effect of corrosion, cost of repair and remedial measures are briefly outlined.

Effects of Alternating Currents in Causing Corrosion. F. E. Kulman. Paper DMC-60-3. (New York: American Gas Association, 1960, $.25.)

A brief historical review and an outline of the present status is presented. The problem of interest and importance is: under what conditions can a-c electrolysis occur or be prevented from occurring. The subject of a-c corrosion requires a large amount of systematic work to achieve any definite results. Until results of research investigations are received, it will not be possible to evaluate the degree of existing corrosion hazards caused by a-c voltages and currents.

Hydrogen Diffusion Corrosion Problems in a Fluid Catalytic Cracker and Gas Plant. E. F. Ehmke. *Corrosion 16,* 246t (1960) May (7 pp.)

Account of corrosion problems in a fluid catalytic cracker and gas plant following a 19,000-hr run. Specific places where corrosion damage occurred and was examined include: 1) the carbon-moly steel reactor, 2) the regenerator, 3) catalyst lines, and 4) the gas plant. It was found that corrosion became a problem when coupled with erosion in cyclones or diffuser grids. Alloying could not be justified except on stressed parts. Hydrogen blistering is discussed in detail. It was found that its occurrence in the gas plant was a function of *p*H downstream of the water wash tower. As the *p*H increased in the absorber deethanizer, so did the hydrogen penetration rate.

Prevention of Sulfide-Stress Cracking in Sour-Condensate Well Equipment. W. J. McGuire and L. W. Vollmer. *J. Eng. Ind. 82,* 93 (1960) May (8 pp.)

Present concepts of requirements for sour-condensate well equipment indicate several materials considerations. When well conditions permit, grade J-55 tubing made from plain carbon steel should be used. If requirements are such that J-55 is inadequate, specially processed N-80 is indicated. Experience has shown that the carbon-manganese-molybdenum steels and AISI 4140 or 4145 can be rendered insensitive to sulfide stress cracking by tempering. Critical components of wellhead equipment that require materials with hardnesses of Rockwell-C 30 or greater should be made of K-Monel. Equipment that is fabricated by welding or which may be repaired by welding should be thermally processed after welding to limit hardness. For carbon steels, this can be accomplished by tempering to 1150°F.

An Up-to-date Corrosion Control Program for a Gas Distribution Company. D. P. Price. Paper DMC-60-21. (New York: American Gas Association, 1960, $.25.)

Article covers most of the phases of a corrosion elimination program in a gas distribution system presenting ideas and techniques which will help accomplish this goal. Sound engineering, testing, correct material application, proper installation, education and cooperation are absolute necessities for a successful program.

Inhibitors

The Use of Heterocyclic Tertiary Amines for the Control of Corrosion Caused by Flue Gases. E. B. Davies and B. J. Alexander. *J. Inst. Fuel. 33,* 163 (1960) April (13 pp.)

Availability and origin of heterocyclic tertiary amines are indicated. The development of these products for the control of "cold end" acid corrosion inhibition is traced with details of laboratory experimental work followed by pilot plant probe tests leading to full scale installations on boiler plant of various descriptions including ships' air heaters and economizers. The coagulating effect of these amines on stack solids is also noted together with a description of experimental work carried out to assess this phenomenon. Corrosion inhibition amounting to at least 80 per cent is claimed for air heaters and economizers.

12. ANALYTICAL METHODS AND TESTS

Carbon Dioxide

Total Carbon Analyser, the "Gaz de France" Model. R. Liard. *J. Ind. Gaz 84,* 98 (1960) March (2 pp.)

Indirect measure of the volume of combustion products of a gas appliance by CO_2 analysis in the flues is outlined. Design, operation, gauging, survey and precision of the infrared ONERA analyser is discussed.

Gas Analysis

Gas Sampler under Pressure. A. Gouffe and H. Gaudry. *J. Ind. Gaz 84,* 100 (1960) March (2 pp.)

In this device the extracted gas is proportional to the absolute pressure and to the metered volume of the crude gas flow. The design, operation and application of this gas sampler is discussed.

Sensitive Thermal Conductivity Gas Analyzer. J. R. Purcell and R. N. Keeler. *Rev. Sci. Instruments 31,* 304 (1960) March (3 pp.)

A thermal conductivity gas analyzer has been designed using ac excitation for the thermal conductivity cell. This has greatly reduced drift and has increased sensitivity. The unit has a minimum range of 200 ppm N_2 in H_2 for full scale deflection. Stability and noise level are equivalent to about 10 parts per million nitrogen in hydrogen. The time required to complete a reading on a sample is about 30 sec.

Hydrocarbons

Molecular Sieve Adsorption. Application to Hydrocarbon Type Analysis. J. G. O'Connor and M. E. Norris. *Anal. Chem. 32,* 701 (1960) May (4 pp.)

Method is described for the determination of normal hydrocarbons in 100° to 650°F petroleum distillates using powdered molecular sieves without prior fractionation of the distillates into narrow boiling cuts. The accuracy, calculated as a standard deviation, is to ± 0.8% of the normal hydrocarbon content of the sample. The procedure consists of weighing the sample into an adsorption column containing the sieves and eluting the nonadsorbed hydrocarbons with isopentane. The excess

eluent is removed by vacuum evaporation at room temperature, and the adsorbed normal hydrocarbon content determined by weighing. Also described is a procedure for recovering the adsorbed normal hydrocarbons from the sieves by extraction with n-pentane.

Hydrogen

Interaction of Beta Particles with Matter. Quantitative Determination of Hydrogen, Carbon, Nitrogen, Oxygen and Fluorine Materials. P. R. Gray, D. H. Clarey and W. H. Beamer. *Anal. Chem. 32,* 582 (1960) May (8 pp.)

Binary and ternary compounds and mixtures can be uniquely analyzed by a measurement of their β-ray transmittance and backscatter intensities. A mathematical equation for β-ray backscattering has been developed which correlates the experimental data with the theoretical sample analysis. The standard deviation in the experimentally determined weight fraction of hydrogen in hydrocarbons and in hydrogen-containing ternary compounds is less than 0.03%. Analysis of ternary compounds is fast, simple, accurate and nondestructive.

Oxygen

Removal of Oxygen from Methane and the Use of Nuclear Spin Relaxation to Measure Oxygen Concentration. H. S. Sandhu, J. Lees and M. Bloom. *Can. J. Chem. 38,* 493 (1960) April (3 pp.)

Nuclear spin relaxation measurements are used to measure quantitatively the amount of oxygen present in methane. An upper limit of 2.5×10^{-4}% is placed on the amount of oxygen present in methane after treatment with a getter made of misch metal.

Particle Size

Particle Size Analysis in Routine Process Control. A. G. Pendleton. *Chem. Process Eng. 41,* 147 (1960) April (2 pp.)

When particle size analysis is used in process control the primary demands made on the apparatus are simplicity in operation, rapid production of results and good reproducibility. To these conditions should be ideally added a fourth, namely, accuracy over a wide range of materials and of particle sizes. An instrument which has been built with these specifications in mind is the Fisher sub-sieve sizer. This apparatus is based on air permeability principles, but is said to incorporate certain refinements which reduce the obvious sources of error in this method.

Pyrolysis

Pyrolysis as an Analytical Tool. R. N. Rogers, S. K. Yasuda and J. Zinn. *Anal. Chem. 32,* 672 (1960) May (7 pp.)

New, simple instrument is proposed to replace the thermobalance. Pyrolysis curves of organic and inorganic compounds approximate the first derivative of the thermogravimetric pyrolysis curve. A theoretical discussion indicates how pyrolysis data may be used to obtain kinetic constants. A number of organic and inorganic pyrolysis curves are presented.

Radioactivity Applications

Mass Spectrometric Studies of Ionic Intermediates in the Alpha-Particle Radiolysis of Ethylene. C. E. Melton and P. S. Rudolph. *J. Chem. Phys. 32,* 1128 (1960) April (4 pp.)

Two techniques were used for the elucidation of ion-molecule reaction mechanisms in the alpha radiolysis of C_2H_4 in the new alpha-particle mass spectrometer. The corresponding variations in the present of primary, secondary and tertiary ions over a tenfold pressure range were used to postulate the reaction mechanisms. Mixtures of the C_2 hydrocarbons were employed to increase the relative concentrations of a specific reactant ion, thus independently confirming the postulated mechanisms. Conclusions as to reaction mechanisms drawn from this study are compared to those drawn from the appearance potential technique used in the electron impact studies.

Radioisotopes without Tears. J. S. Fawcett. *Research/Development 11,* 5 (1960) April (9 pp.)

General information on the availability of isotopes as well as a guide to handling equipment is presented. The problem of proper shielding and safety in laboratory and industry are outlined.

Surface Area

Krypton Adsorption and the Surface Area of Silica. K. S. W. Sing and D. Swallow. *J. Appl. Mech. 10,* 171 (1960) April (5 pp.)

Details are given of the apparatus used for measuring adsoption isotherms of krypton at −196°, which allowed a rapid and precise measurement of pressures. Surface areas have been calculated by the Brunauer, Emmett and Teller method (B.E.T.), from the krypton adsorption isotherms on samples of ground quartz and silica gel. It was not possible to obtain a 'standard' curve from the krypton adsorption isotherms on the nonporous silicas, but when these isotherms were plotted in logarithmic form, all gave a substantial linear region with the same slope. The logarithmic plot of the isotherm on the silica gel has a different slope; it seems that capillary condensation occurred on this sample at low pressure and that the B.E.T. area is invalid here.

X-Ray Techniques

X-Ray Absorption and Emission. H. A. Liebhafsky, E. H. Winslow and H. Pfeiffer. *Anal. Chem. 32,* 240 R (1960) April (9 pp.)

This review covers the following topics: scattering, absorption, X-ray emission spectrography, commercial X-ray emission spectography, microprobes and film thickness. Other major sources of information in the recent general literature are indicated.

Effects Due to Chemical State of the Samples. P. D. Zemany. *Anal. Chem. 32,* 595 (1960) May (3 pp.)

Experimental results show that the chemical state of an element can affect the structure and position of an absorption edge and both the wave length and intensity of an emission line. The measurements were made with a

conventional X-ray spectrograph. In some cases it may be necessary to consider these effects in X-ray emission analysis.

13. BASIC SCIENCE

Absorption

Absorption of Hydrogen by Palladium/Platinum Alloys. A. W. Carson, T. B. Flanagan and F. A. Lewis. Part 2. *Trans. Faraday Soc. 56,* 371 (1960) March (11 pp.)
The course of absorption of hydrogen from hydrochloric acid solutions by a series of palladium/platinum alloys was followed by measurement of relative electrical resistance and electrode potentials. Over the region of constant rate the activation energy for absorption from solution was found to be about zero and the rate to be first order with respect to hydrogen pressure. A possible mechanism of absorption is discussed.

The Palladium + Hydrogen Equilibrium at High Pressures and Temperatures. P. L. Levine and K. E. Weale. *Trans. Faraday Soc. 56,* 357 (1960) March (7 pp.)

Isotherms of the palladium + hydrogen system have been determined up to 990 atm at supercritical temperatures from 326° to 477°C. At the highest pressures the atomic ratio H/Pd in the solid phase exceeds 0.59, assumed as a limiting value in Lacher's theory although the theoretical equation reproduces the general features of the isotherms, which show the persistence of H + H interaction above the critical region. The new isotherms are correlated with existing measurements for the critical region and for the same pressure range at low temperatures. The electrical resistance of the solid phase has also been measured.

Adsorption

Adsorptive Properties of Polymer Carbons. J. J. Kipling and R. W. Wilson. *Trans. Faraday Soc. 56,* 557 (1960) April (5 pp.)

Adsorptive capacities for water and a number of organic substances shown by a range of polymer carbons are compared with those of polyvinylidene chloride (Saran) carbon and a typical coconut shell charcoal. The polyvinylidene chloride carbon is remarkable for its high capacity when unactivated, rather than its molecular-sieve action which, in some respects, is found in other carbons.

Fluid Flow

The Upward Vertical Flow of Air-Water Mixtures. R. A. S. Brown, G. A. Sullivan and G. W. Govier. *Can. J. Chem. Eng. 38,* 62 (1960) April (5 pp.)

Results of measurements of pressure drop and holdup are reported over a range of air and water rates for the upward vertical flow of air-water mixtures in a 1.50 inch I.D. tube with average air densities ranging from 0.092 to 0.552 lb/ft^3. Superficial water velocities were between 0.0695 and 7.35 ft/sec. The average density of the gas phase has a more or less marked effect on all three regime transitions. The transitions all shift similarly to lower air-water discharge volume ratios with increasing gas phase density. While the flow patterns were not directly observed in the investigation here reported, the flow pattern transitions would be expected to behave similarly.

Heat Transfer

Heat Transfer. E. R. G. Eckert, J. P. Hartnett, T. F. Irvine, Jr. and E. M. Sparrow. *Ind. Eng. Chem. 52,* 327 (1960) April (13 pp.)

This thorough and fundamental review in heat transfer covers the past and present trends in research in this particular field. Astronautical developments seem to be responsible for research on the influence of chemical reaction, phase changes and low density conditions. About 290 references are given.

Heat-Transfer Coefficients for a Full-Scale Pebble-Bed Heater. R. B. Lancashire, E. A. Lezberg and J. F. Morris. *Ind. Eng. Chem. 52,* 433 (1960) May (2 pp.)

A regenerative pebble-bed heat exchanger is used to heat air for hypersonic flight research. During the initial operation of this facility, a program was carried out to obtain data concerning heat-transfer coefficients in a packed bed of spheres. A description is given of the facility design, operation and instrumentation. The heat-transfer analysis and the results of this study indicate heat-transfer coefficients lower than previously indicated in the literature, but in reasonable agreement with other studies on large packed beds.

Turbulent Heat and Mass Tranfer from Stationary Particles. I. S. Pasternak and W. H. Gauvin, *Can. J. Chem-Eng. 38,* 35 (1960) April (8 pp.)

Convective heat and mass transfer rates for 20 shapes suspended in various orientations in a hot turbulent air stream were correlated by an equation for turbulent intensities between 9 and 10%, using a new characteristic dimension, L″, in the Reynolds Number. This dimension, defined as the total surface area divided by the maximum perimeter perpendicular to flow, was qualitatively explained from boundary layer considerations and was found to correlate the data for different shapes available in the literature. Qualitative pictures for the relative rates of heat and mass transfer around the various shapes were also obtained.

Hydrogen

Compilation of Thermodynamic Properties, Transport Properties, and Theoretical Rocket Performance of Gaseous Hydrogen. C. R. King. Tech Note D-275. Washington: Nat. Aero and Space Admin., April, 1960.

Data were computed assuming equilibrium composition during an isentropic expansion using normal hydrogen as the propellant for chamber pressures from 0.146960 to 1469.60 lb/in^2 absolute pressure ratios from 1 to 3000 and chamber temperatures from 600° to 5000°K. Computed parameters are nozzle-exit pressure and temperature, enthalpy, molecular weight, isentropic exponent, specific heat at constant pressure, absolute viscosity, thermal conductivity, Mach number, specific impulse in vacuum, ratio of nozzle-exit to throat areas, thrust co-

efficient, specific impulse, equilibrium gas composition, characteristic velocity and entropy. Additional data show some of the properties of gaseous normal hydrogen, orthohydrogen and parahydrogen at temperatures below 600°K for several pressures.

Kinetics

Concerning the Problem of the Influence of Internal Degrees of Freedom of Particles on the Transport Coefficients of a Multicomponent Mixture of Gases. E. V. Samuilov. *ARS J. 30,* 388 (1960) April (6 pp.)

An analysis of the influence of the internal degrees of freedom of particles on the kinetic coefficients was carried out earlier by many investigators. However, these papers have one common shortcoming. The diameters for elastic scattering, which can be strictly calculated on the basis of quantum-mechanical collision theory, were replaced by various artificial mechanisms for the transfer of energy from the internal degrees of freedom of the particles to the translational degrees of freedom. In this paper the author used the probabilities of various types of molecular collisions, obtain quantum-mechanically by various investigators. The system of generalized kinetic equations is solved by the Enskog method.

Mass Transfer

Mass Transfer. C. R. Wilke, J. M. Prausnitz and A. Acrivos. *Ind. Eng. Chem. 52,* 441 (1960) May (6 pp.)

During the past year, no major breakthroughs of fundamental importance were noted. A number of studies were concerned with fundamental analysis of systems of well-defined physical geometry, including natural convection from spheres at high Schmidt numbers and mass transfer from rotating disks. Further knowledge was developed for diffusion in gases at high temperature and pressure and for thermal diffusion column theory. The possible importance of surface tension gradients in distillation columns was pointed out. Studies of dispersed fluid phases including bubble growth and circulation velocities in drops. 82 references are listed.

Permeability

Evaluating Marshall's Formula for Permeability. G. H. F. Gardner and J. H. Messmer. *World Oil 150,* 150 (1960) April (4 pp.)

The relationship between capillary pressure and the permeability of porous media is a problem common to the petroleum engineer and the soil scientist. Their investigations, however, often proceed independently. Recent contributions to the problem from both fields are compared and assessed in this article. Experimental results indicated a weakness in Marshall's formulas, calculated absolute permeabilities being too low by a constant factor and relative permeabilities too high. However, ideas used by Marshall were used to develop modified formulas.

Thermal Conductivity

Theoretical and Experimental Investigation of Heat Conduction in Air, Including Effects of Oxygen Dissociation. C. F. Hansen, R. A. Early, F. E. Alzofon and F. C. Witteborn. *Nat. Aero. Space Admin.,* Tech. Rep. R-27. Washington: Govt. Print. Off., 1959, $0.40 (25 pp.)

Solutions are presented for the conduction of heat through a semi-infinite gas medium having a uniform initial temperature and a constant boundary temperature. The coefficients of thermal conductivity and diffusivity are treated as variables, and the solutions are extended to the case of air at temperatures where oxygen dissociation occurs. These solutions are used together with shock-tube measurements to evaluate the integral of thermal conductivity for air as a function of temperature.

Thermodynamics

Applied Hydrocarbon Thermodynamics. Part 16. W. C. Edmister. *Petrol. Refiner 39,* 193 (1960) April (7 pp.)

The integral method for petroleum fraction equilibrium vaporization calculations was given in parts 14 and 15. This previous material is now supplemented by a comparison showing the advantage of the integral method, and new true boiling point transformation charts for estimating the true boiling point assays for equilibrium vapor and liquid. A few equilibrium flash vaporization calculations included show the advantage of the integral method.

Thermodynamics of Gases. (Encyclopedia of Physics *12*). S. Flügge. Springer Verlag, Berlin-Göttingen-Heidelberg, 1958. $36. (132 pp.)

This volume of the Handbuch der Physik consists of six articles which cover the properties and kinetic theory of real gases, transport phenomena of gases at medium pressures, general vacuum physics and production as well as measurement of ultrahigh vacuum. Each article is written in English or in German as indicated by its title.

Viscosity

Molecular Transport Properties of Fluids. E. F. Johnson. *Ind. Eng. Chem. 52,* 447 (1960) May (4 pp.)

This review is concerned with the important publications on the viscosity and thermal conductivity of homogeneous, Newtonian fluids which have appeared from October 1958 through most of 1959. Of particular interest are experimental methods and theoretical or empirical methods of estimating properties. In contrast with past years a considerable effort has been expended in studies of the effects of pressure on viscosity.

Adsorption

Adsorption Process. R. M. Barrer (assigned to Union Carbide Corp.) U. S. 2,930,447 (1960) March 29.

Oxygen is preferentially adsorbed on a chabazite molecular sieve from an admixture with nitrogen or argon by first dehydrating the chabazite, then adsorbing thereon ammonia in amounts of 0.061 g NH_3 per g and then selectively adsorbing oxygen. Methylamine may be likewise adsorbed on mordenite to increase the capacity of mordenite for hydrogen, whereby mixtures of hydrogen and oxygen may be separated.

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California Oil World
Canadian Chemical Processing
Canadian Gas Journal
Canadian Journal of *Chemical Engineering*
Canadian Journal of *Chemistry*
Canadian Journal of *Physics*
Ceramics (British)
Chemical and *Engineering Data,* Journal of
Chemical and *Engineering News*
Chemical & Process Engineering
Chemical Education, Journal of
Chemical Engineering
Chemical Engineering Progress
Chemical Physics, Journal of
Chemical Processing
Chemical Reviews
Chemical Society, Journal of (British)
Chemical Society, Proceedings (British)
Chemical Week
Chemistry & Industry (British)
Coal-Heat
Coal Utilization
Coke and Gas (British)
College Placement, Journal of
Combustion
Combustion and Flame (British)
Communications of the ACM
Compressed Air
Computers and Automation
Construction Methods and Equipment
Control Engineering
Corrosion
Corrosion Technology (British)
Cost Engineering
Datamation
Design News
Drilling
Electronics
Engineering for Industry, Journal of
Engineering for Power, Journal of
Engineers' Digest (British)
Erdöl und Kohle (German)
Faraday Society, Transactions of (British)
Fuel (British)
Fuel Efficiency (British)
Fueloil & Oil Heat
Gas
Gas Age
Gas & Oil Power (British)
Gas Council Research Communications (British)
Gas Heat and Comfort Cooling
Gas Industries
Gas Journal (British)
Gas Service and Domestic Coke
Gas Times (British)
Gas- und Wasserfach (German)
Gas World (British)
Gazovaya Promyshlennost (Russian)
Heating, Piping & Air Conditioning
Heat Transfer, Journal of
Independent Petroleum Association of America *Monthly*
Industrial and *Engineering Chemistry*
Industrial Finishing (British)
Industrial Gas (American)
Industrial Gas (British)
Industrial Heating
Industrial Research
Industries du Gaz, Journal des (French)
Institute of Fuel, Journal of (British)
Institute of Gas Technology Research Bulletins
Institute of Petroleum, Journal of (British)
Institution of Gas Engineers Bulletins and *Communications* (British)
Instrumentation
Instruments and Control Systems
Izvestiya Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk (Russian)
Khimiya i Tekhnologiya Topliva i Masel (Russian)
LP-Gas
Lubrication
Lubrication Engineer
Mathematical Aids to Computation
Mechanical Engineering
Metals, Journal of
National Aeronautics and Space Administration Memorandum
National Fire Protection Association Quarterly
National Gas Bulletin of Australia
National Petroleum News
Nuclear Science and Engineering
Nucleonics
Oil and *Gas* Journal
Optical Society of America, Journal of
Organic Chemistry, Journal of
Petro/Chem Engineer
Petroleum (British)
Petroleum Engineer, The (Drilling and Producing)
Petroleum Engineer, The (for Management)
Petroleum Refiner
Petroleum Technology Journal of
Petroleum Week
Physical Chemistry, Journal of
Physics and Chemistry of Solids (British)
Physics of Fluids (British)
Physics Today
Pipeline Engineer
Pipe Line Industry
Pipeline News
Power
Producers Monthly
Product Engineering
Progress (Pakistan)
Public Utilities Fortnightly
Research/Development
Research, Journal of, *A. Physics* and *Chemistry*
Research, Journal of, *B. Mathematics and Mathematical Physics*
Research, Journal of, *C. Engineering* and *Instrumentation*
Review of Scientific Instruments
Revue Generale du Gaz (Belgian)
Rivista dei Combustibili (Italian)
Science
Scientific Instruments, Journal of (British)
Solid-State Electronics
Stroitel'stvo Truboprovodov (Russian)
Svenska Gasverksföreningens Månadsblad (Swedish)
Technical News Bulletin
U.S. Bureau of Mines Bulletins, Information Circulars and *Reports of Investigations*
U.S. Patents
Uspekhi Khimii (Russian)
World Oil
World Petroleum